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THERMAL CONDUCTIVITY OF PARTICULATE MATERIALS:
A SUMMARY OF MEASUREMENTS TAKEN AT THE
MARSHALL SPACE FLIGHT CENTER

By James A. Fountain, Ronald W. Scott,
and Edward A. West
Space Sciences Laboratory

April 20, 1973

NASA

*George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama*

1. REPORT NO. TM X- 64759	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE Thermal Conductivity of Particulate Materials: A Summary of Measurements Taken at the Marshall Space Flight Center		5. REPORT DATE April 20, 1973	6. PERFORMING ORGANIZATION CODE
		8. PERFORMING ORGANIZATION REPORT #	
7. AUTHOR(S) James A. Fountain, Ronald W. Scott, and Edward A. West		10. WORK UNIT NO.	11. CONTRACT OR GRANT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812		13. TYPE OF REPORT & PERIOD COVERED Technical Memorandum	
		14. SPONSORING AGENCY CODE	
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D.C. 20546			
15. SUPPLEMENTARY NOTES Prepared by Space Sciences Laboratory, Science and Engineering			
16. ABSTRACT Thermal conductivity measurements of particulate materials in vacuum are presented in summary. Particulate basalt and soda lime glass beads of various size ranges were used as samples. The differentiated line heat source method was used for the measurements. A comprehensive table is shown giving all pertinent experimental conditions. Least-squares curve fits to the data are presented for $K = A + BT^3$ and $K = A + BT + CT^3$. The latter equation is shown to give a slightly better fit to the data in most cases. In the relatively low vacuum data, the curves $K = A + BT$ and $K = A + BT + CT^2$ were fitted to the data.			
EDITOR'S NOTE Use of trade names or names of manufacturers in this report does not constitute an official endorsement of such products or manufacturers, either expressed or implied, by the National Aeronautics and Space Administration or any other agency of the United States Government.			
17. KEY WORDS		18. DISTRIBUTION STATEMENT Unclassified-unlimited <i>James A. Fountain</i>	
19. SECURITY CLASSIF. (of this report) Unclassified	20. SECURITY CLASSIF. (of this page) Unclassified	21. NO. OF PAGES 72	22. PRICE NTIS

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THERMAL CONDUCTIVITY OF PARTICULATE MATERIALS: A SUMMARY OF MEASUREMENTS TAKEN AT THE MARSHALL SPACE FLIGHT CENTER

INTRODUCTION

This report is a summary of approximately 1100 separate thermal conductivity tests of particulate materials conducted in the Space Sciences Laboratory of the Marshall Space Flight Center from 1965 to 1972. The tests were taken under a variety of programs and most of the data have been published previously [1, 2, 3, 4]. A complete description of the method of measurement, the differentiated line heat source, is given by Merrill [5] and Scott and Fountain [6].

Thermal conductivity was measured as a function of sample material, particle size, temperature, bulk density, chamber pressure, interstitial gas, and sample surface loading (which was used to simulate depth). The apparatus used in the tests was the same in all cases except as noted in Table 1, where the measurement was made using the conventional line heat source techniques as described by Salisbury and Glaser [7].

EXPLANATION OF DATA PRESENTATION

Four equations were curve-fitted to each set of data points by a least squares fit routine. They are: $K = A + BT + CT^3$, $K = A + BT^3$, $K = A + B/T + CT^3$, and $K = e^{A + BT}$. The first three equations were taken from the literature and are based on theoretical considerations [2]. The fourth equation was chosen so that a straight line could be curve-fitted to the data when plotted on semilog paper. Table 1 lists the variables for the different test series and gives the figure and table numbers for the data points. Table 1 also lists the values of the standard deviation for each curve fit. The standard deviations are significant only between the four equations curve-fitted to the same data points and not between the different test series without normalization. Graphs of

$K = A + BT + CT^3$ and $K = A + BT^3$ are shown for comparison for each set of data points in Figures 1 through 23. Graphs of $K = A + B/T + CT^3$ and $K = e^{A + BT}$ are not shown, but the A, B, and C coefficients are given in Table 2 for all four equations.

Figures 24 through 27 show the results of thermal conductivity tests taken on the samples in the vacuum range of $6.9 \times 10^2 \text{ N/m}^2$, using CO_2 as the interstitial gas. A straight line $K = A + BT$ and a second-degree polynomial $K = A + BT + CT^2$ were fitted through the data points. The A, B, and C coefficients for these two equations are also given in Table 2.

Tables 3 through 29 give the thermal conductivity and corresponding temperature for each data point.

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TABLE 1. DATA SUMMARY

Figure No.	Table No.	Sample	Particle Size (μm)	Temperature Range ($^{\circ}\text{K}$)	Density (g/cm^3)	Chamber Pressure		Sample Load (g/cm^2)	Standard Deviations for Curve Fits ($\times 10^{-3}$)			
						(N/m^2)	(TORR)		$K = A + BT + CT^3$	$K = A + BT^3$	$K = A + B/T + CT^3$	$K = e^{A+BT}$
1	3	Basalt	37 — 62	179-365	0.79	1.3×10^{-6}	1×10^{-3}	0	0.03	0.03	0.03	0.03
2	4	Basalt	37 — 62	152-367	0.88	1.3×10^{-6}	1×10^{-3}	0	0.05	0.05	0.05	0.05
3	5	Basalt	37 — 62	159-361	0.98	1.3×10^{-6}	1×10^{-3}	0	0.09	0.10	0.10	0.10
4	6	Basalt	37 — 62	140-370	1.13	1.3×10^{-6}	1×10^{-3}	0	0.04	0.08	0.04	0.05
5	7	Basalt	37 — 62	149-370	1.30	1.3×10^{-6}	1×10^{-3}	0	0.05	0.05	0.05	0.07
6	8	Basalt	37 — 62	133-367	1.50	1.3×10^{-6}	1×10^{-3}	0	0.07	0.13	0.07	0.07
7	9	Glass Beads*	30 — 38	118-371	1.58	1.3×10^{-6}	1×10^{-3}	0	0.22	0.22	0.22	0.26
8	10	Glass Beads	30 — 38	124-373	1.58	1.3×10^{-6}	1×10^{-3}	0	0.13	0.13	0.13	0.13
9	11	Glass Beads	590 — 840	190-297	1.50	1.3×10^{-6}	1×10^{-3}	0	0.76	0.76	0.76	0.76
10	12	Glass Beads	590 — 840	208-296	1.50	1.3×10^{-6}	1×10^{-3}	150	2.5	2.6	2.5	2.6
11	13	Glass Beads	590 — 840	178-298	1.58	1.3×10^{-6}	1×10^{-3}	198	0.6	0.6	0.6	0.7
12	14	Glass Beads	590 — 840	131-300	1.58	1.3×10^{-6}	1×10^{-3}	348	1.1	1.1	1.1	1.1
13	15	Glass Beads	590 — 840	199-309	1.58	$1.3 \times 10^{-2} \text{ N}_2$	$1 \times 10^{-4} \text{ N}_2$	150	1.2	1.6	1.2	1.5
14	16	Glass Beads	590 — 840	129-297	1.58	$1.3 \times 10^{-1} \text{ N}_2$	$1 \times 10^{-3} \text{ N}_2$	348	0.9	1.5	1.0	1.2
15	17	Glass Beads	590 — 840	204-299	1.58	$1.3 \times 10^{-1} \text{ N}_2$	$1 \times 10^{-3} \text{ N}_2$	150	1.0	1.4	1.0	1.4
16	18	Glass Beads	590 — 840	215-297	1.58	1.3 N_2	$1 \times 10^{-3} \text{ N}_2$	150	1.7	2.1	1.7	2.1
17	19	Glass Beads	590 — 840	176-295	1.51	3.25 N_2	$2.5 \times 10^{-5} \text{ N}_2$	0	0.99	1.16	1.01	1.14
18	20	Glass Beads	590 — 840	136-297	1.58	3.25 N_2	$2.5 \times 10^{-5} \text{ N}_2$	348	0.6	1.4	0.7	1.2
19	21	Glass Beads	590 — 840	122-296	1.51	5.85 N_2	$4.5 \times 10^{-5} \text{ N}_2$	0	1.06	1.07	1.06	1.13
20	22	Glass Beads	590 — 840	224-296	1.58	6.5 N_2	$5.0 \times 10^{-5} \text{ N}_2$	0	0.4	1.0	0.4	1.0
21	23	Glass Beads	590 — 840	198-301	1.58	6.5 N_2	$5.0 \times 10^{-5} \text{ N}_2$	150	1.0	1.2	1.0	1.2
22	24	Glass Beads	590 — 840	127-297	1.58	6.5 N_2	$5.0 \times 10^{-5} \text{ N}_2$	348	0.9	2.1	1.1	1.8
23	25	Glass Beads	590 — 840	191-298	1.58	13 N_2	$1 \times 10^{-1} \text{ N}_2$	150	1.3	1.3	1.3	1.3
						(N/m^2)	(mb)		A + BT	A + BT + CT ²		
24	26	Glass Beads	30 — 38	193-305	1.58	$6.9 \times 10^2 \text{ CO}_2$	7 CO_2	0	1.3	1.3		
25	27	Basalt	37 — 62	206-318	0.79	$6.9 \times 10^2 \text{ CO}_2$	7 CO_2	0	0.4	0.4		
26	28	Basalt	37 — 62	222-304	1.13	$6.9 \times 10^2 \text{ CO}_2$	7 CO_2	0	0.6	0.6		
27	29	Basalt	37 — 62	207-365	1.50	$6.9 \times 10^2 \text{ CO}_2$	7 CO_2	0	0.5	0.5		

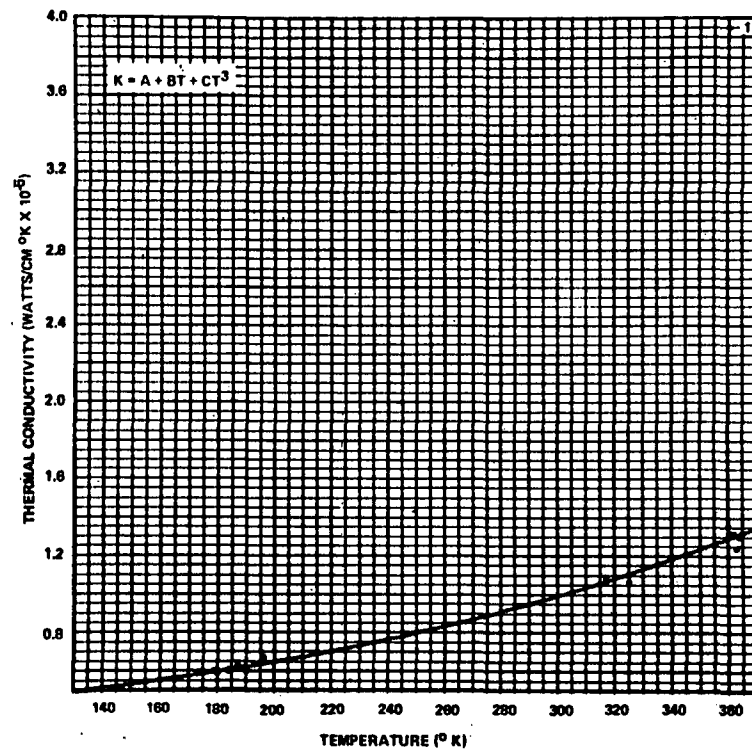
*. Conductivity measured by conventional line heat source method; all others measured by differentiated line heat source. The basalt sample is an Oregon basalt, the source of which is described in Reference 3. The 30- to 38- μm glass beads were manufactured by Microbeads, Inc., and the 590- to 840- μm beads by the Cataphote Corp.

TABLE 2. A, B, AND C COEFFICIENTS FOR EACH CURVE FIT

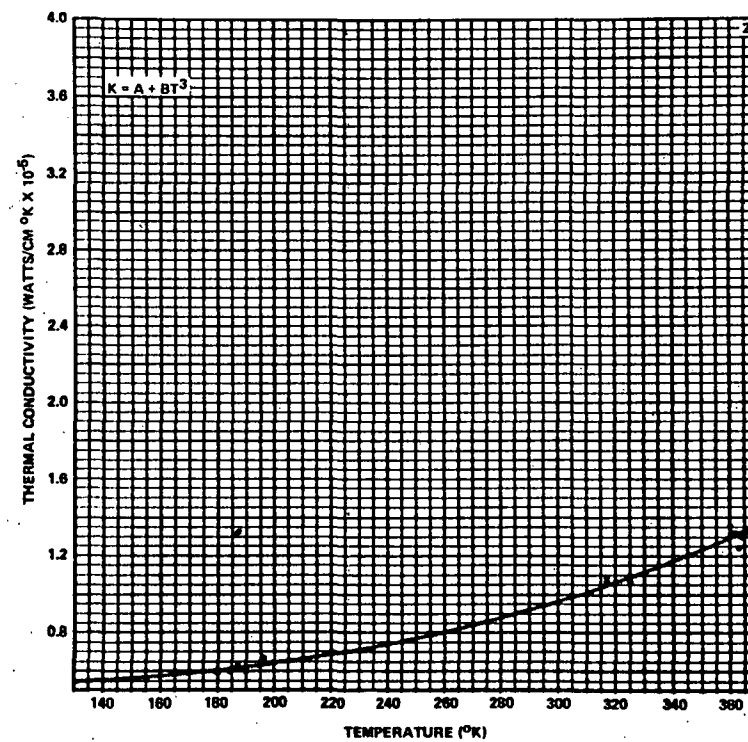
Figure No.	Table No.	Coefficients for $K = A + BT + CT^3$			Coefficients for $K = A + BT^3$		Coefficients for $K = A + B/T + CT^3$			Coefficients for $K = e^{(A+BT)}$	
		A	B	C	A	B	A	B	C	A	B
1	3	3.011×10^{-6}	1.294×10^{-8}	1.128×10^{-13}	5.086×10^{-6}	1.691×10^{-13}	7.805×10^{-6}	-4.737×10^{-4}	1.380×10^{-13}	-1.280×10^1	4.271×10^{-3}
2	4	6.123×10^{-6}	2.551×10^{-9}	1.566×10^{-13}	6.590×10^{-6}	1.666×10^{-13}	6.341×10^{-6}	4.942×10^{-6}	1.693×10^{-13}	-1.252×10^1	3.756×10^{-3}
3	5	1.981×10^{-6}	2.640×10^{-8}	5.660×10^{-14}	6.183×10^{-6}	1.808×10^{-13}	9.863×10^{-6}	-6.308×10^{-4}	1.315×10^{-13}	-1.256×10^1	3.910×10^{-3}
4	6	3.257×10^{-6}	3.659×10^{-8}	1.204×10^{-14}	8.735×10^{-6}	1.857×10^{-13}	1.457×10^{-5}	-9.140×10^{-4}	1.067×10^{-13}	-1.211×10^1	3.177×10^{-3}
5	7	1.202×10^{-5}	2.141×10^{-9}	2.333×10^{-13}	1.236×10^{-5}	2.432×10^{-13}	1.264×10^{-5}	-4.677×10^{-5}	2.396×10^{-13}	-1.170×10^1	2.820×10^{-3}
6	8	8.203×10^{-6}	5.412×10^{-8}	8.140×10^{-14}	1.642×10^{-5}	3.430×10^{-13}	2.454×10^{-5}	-1.291×10^{-3}	2.278×10^{-13}	-1.146×10^1	3.080×10^{-3}
7	9	1.115×10^{-5}	-1.559×10^{-8}	5.383×10^{-13}	8.627×10^{-6}	4.684×10^{-13}	6.461×10^{-6}	3.351×10^{-4}	4.984×10^{-13}	-1.213×10^1	4.687×10^{-3}
8	10	2.965×10^{-6}	2.757×10^{-8}	2.502×10^{-13}	7.676×10^{-6}	3.709×10^{-13}	1.154×10^{-5}	-6.968×10^{-4}	3.220×10^{-13}	-1.255×10^1	5.396×10^{-3}
9	11	8.968×10^{-6}	1.678×10^{-8}	1.651×10^{-12}	1.173×10^{-5}	1.738×10^{-12}	1.452×10^{-5}	-5.103×10^{-4}	1.695×10^{-12}	-1.223×10^1	8.249×10^{-3}
10	12	-2.205×10^{-4}	2.225×10^{-6}	-7.614×10^{-12}	1.504×10^{-4}	3.815×10^{-12}	5.183×10^{-4}	-6.847×10^{-2}	-1.781×10^{-12}	-9.368×10^0	3.597×10^{-3}
11	13	8.830×10^{-5}	-6.788×10^{-8}	3.216×10^{-12}	7.759×10^{-5}	2.843×10^{-12}	7.294×10^{-5}	8.143×10^{-4}	2.921×10^{-12}	-1.004×10^1	4.152×10^{-3}
12	14	8.384×10^{-5}	1.080×10^{-7}	2.158×10^{-12}	9.921×10^{-5}	2.813×10^{-12}	1.088×10^{-4}	-1.466×10^{-3}	2.623×10^{-12}	-9.645×10^0	3.260×10^{-3}
13	15	-3.957×10^{-4}	3.056×10^{-6}	-1.061×10^{-11}	1.254×10^{-4}	4.104×10^{-12}	6.098×10^{-4}	-9.199×10^{-2}	-2.554×10^{-12}	-9.709×10^0	4.564×10^{-3}
14	16	-1.323×10^{-3}	9.594×10^{-7}	-2.370×10^{-12}	1.207×10^{-4}	3.609×10^{-12}	2.417×10^{-4}	-1.792×10^{-2}	1.107×10^{-12}	-9.554×10^0	3.754×10^{-3}
15	17	9.985×10^{-4}	-5.136×10^{-6}	2.927×10^{-11}	1.545×10^{-4}	3.222×10^{-12}	-6.621×10^{-4}	1.496×10^{-1}	1.521×10^{-11}	-9.220×10^0	2.945×10^{-3}
16	18	2.109×10^{-3}	-1.181×10^{-5}	6.280×10^{-11}	1.259×10^{-4}	4.537×10^{-12}	-1.727×10^{-3}	3.476×10^{-1}	3.068×10^{-11}	-9.624×10^0	4.373×10^{-3}
17	19	-1.390×10^{-4}	1.140×10^{-6}	-4.240×10^{-12}	3.816×10^{-5}	2.218×10^{-12}	2.071×10^{-4}	-2.909×10^{-2}	-7.619×10^{-13}	-1.106×10^1	6.159×10^{-3}
18	20	-5.892×10^{-5}	1.355×10^{-6}	-4.355×10^{-12}	1.319×10^{-4}	3.892×10^{-12}	3.111×10^{-4}	-2.726×10^{-2}	4.056×10^{-13}	-9.454×10^0	3.710×10^{-3}
19	21	7.061×10^{-5}	-1.080×10^{-7}	2.522×10^{-12}	5.563×10^{-5}	1.813×10^{-12}	3.988×10^{-5}	2.337×10^{-3}	2.173×10^{-12}	-1.017×10^1	3.089×10^{-3}
20	22	2.715×10^{-3}	-1.527×10^{-5}	7.409×10^{-11}	1.008×10^{-4}	4.120×10^{-13}	-2.363×10^{-3}	4.720×10^{-1}	3.408×10^{-11}	-9.355×10^0	8.462×10^{-4}
21	23	4.875×10^{-4}	-2.219×10^{-6}	1.735×10^{-10}	1.244×10^{-4}	6.109×10^{-12}	-2.183×10^{-4}	6.241×10^{-2}	1.113×10^{-11}	-9.691×10^0	5.118×10^{-3}
22	24	-5.017×10^{-5}	1.400×10^{-6}	-4.986×10^{-12}	1.389×10^{-4}	4.552×10^{-12}	3.147×10^{-4}	-2.529×10^{-2}	2.934×10^{-13}	-9.466×10^0	4.145×10^{-3}
23	25	6.430×10^{-5}	6.021×10^{-7}	2.317×10^{-12}	1.607×10^{-4}	5.550×10^{-12}	2.254×10^{-4}	-1.151×10^{-2}	4.507×10^{-12}	-9.330×10^0	4.143×10^{-3}
		$K = A + BT + CT^2$			$K = A + BT$						
24	26	5.498×10^{-6}	5.589×10^{-8}	-1.419×10^{-11}	6.427×10^{-6}	4.857×10^{-8}					
25	27	8.883×10^{-5}	8.920×10^{-8}	1.326×10^{-10}	7.978×10^{-5}	1.590×10^{-7}					
26	28	5.899×10^{-5}	3.155×10^{-7}	-2.648×10^{-10}	7.815×10^{-5}	1.724×10^{-7}					
27	29	6.611×10^{-5}	3.801×10^{-7}	-5.016×10^{-10}	1.061×10^{-4}	9.240×10^{-8}					

TABLE 3. FIGURE 1 DATA

Temperature (° K)	Thermal Conductivity (1×10^{-5} W/cm °K)
179	0.60
180	0.59
184	0.60
184	0.61
187	0.63
190	0.60
196	0.67
317	1.07
317	1.09
325	1.07
360	1.36
361	1.32
362	1.32
363	1.24
364	1.30
365	1.32



a.



b.

SAMPLE: BASALT
PARTICLE SIZE: 37-62 μm

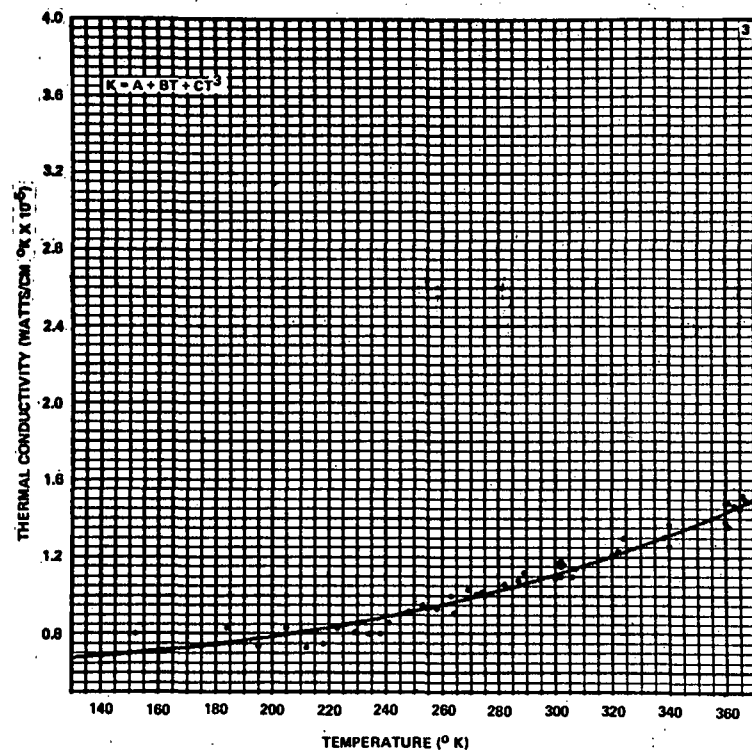
DENSITY: 0.79 g/cm^3
PRESSURE: $1.3 \times 10^{-6} \text{ N/m}^2$

SAMPLE LOAD: 0

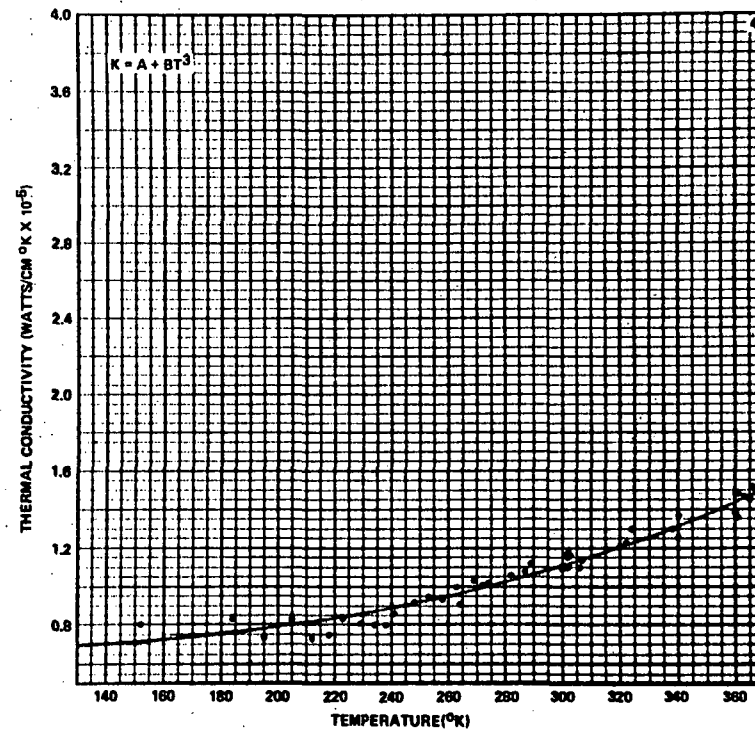
Figure 1. Thermal conductivity of basalt as a function of temperature (density — 0.79 g/cm^3).

TABLE 4. FIGURE 2 DATA

Temperature (° K)	Thermal Conductivity (1×10^{-5} W/cm °K)	Temperature (° K)	Thermal Conductivity (1×10^{-5} W/cm °K)
152.0	0.80	302.0	1.10
184.0	0.83	302.0	1.15
195.0	0.74	302.0	1.17
205.0	0.83	302.0	1.18
212.0	0.73	303.0	1.16
218.0	0.75	306.0	1.10
223.0	0.83	307.0	1.14
229.0	0.81	320.0	1.21
234.0	0.80	322.0	1.23
238.0	0.80	324.0	1.30
241.0	0.86	338.0	1.30
248.0	0.92	340.0	1.26
253.0	0.95	340.0	1.37
258.0	0.93	360.0	1.38
263.0	1.00	360.0	1.38
264.0	0.91	360.0	1.48
269.0	1.03	361.0	1.36
272.0	1.01	361.0	1.36
274.0	1.02	361.0	1.48
282.0	1.06	363.0	1.47
287.0	1.08	365.0	1.45
289.0	1.12	365.0	1.45
300.0	1.09	366.0	1.52
301.0	1.17	367.0	1.50



a.



b.

SAMPLE: BASALT
PARTICLE SIZE: 37-62 μm

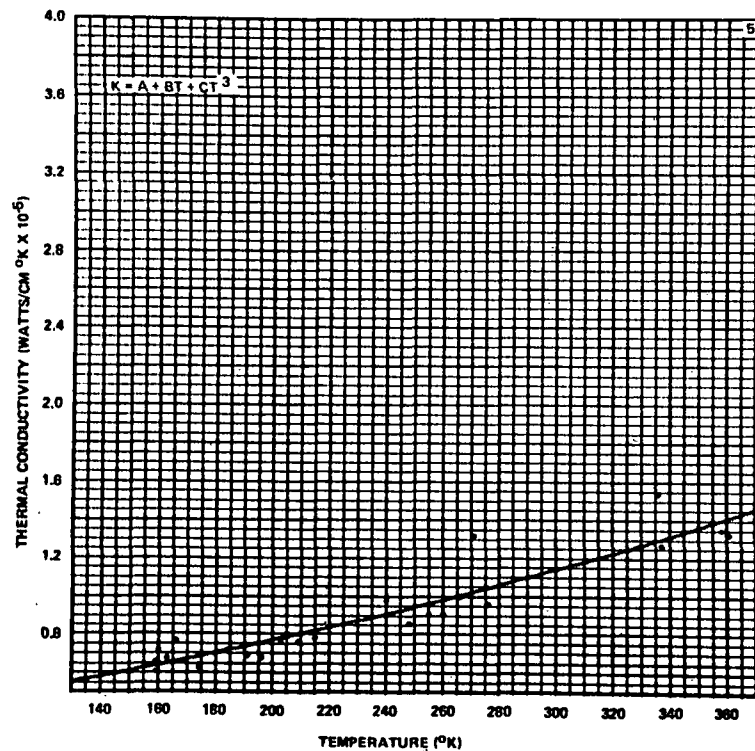
DENSITY: 0.88 g/cm³
PRESSURE: 1.3×10^{-6} N/m²

SAMPLE LOAD: 0

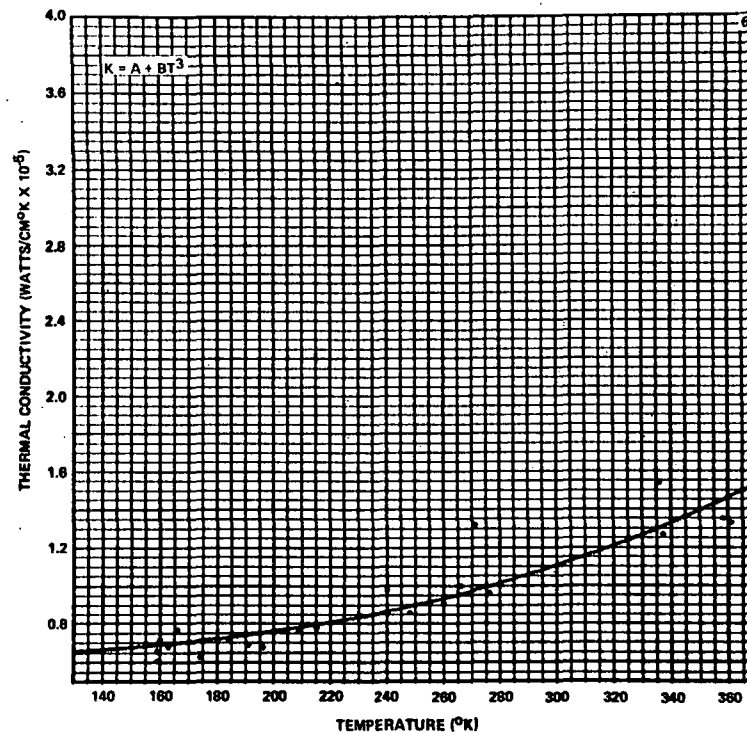
Figure 2. Thermal conductivity of basalt as a function of temperature (density = 0.88 g/cm³).

TABLE 5. FIGURE 3 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)
159	0.61
159	0.66
160	0.72
163	0.68
166	0.77
174	0.63
184	0.72
191	0.69
196	0.68
203	0.76
209	0.76
215	0.78
240	0.98
248	0.86
255	0.91
260	0.91
266	1.00
271	1.32
276	0.96
336	1.54
337	1.27
337	1.27
358	1.35
361	1.33



a.



b.

SAMPLE: BASALT
PARTICLE SIZE: 37-62 μm

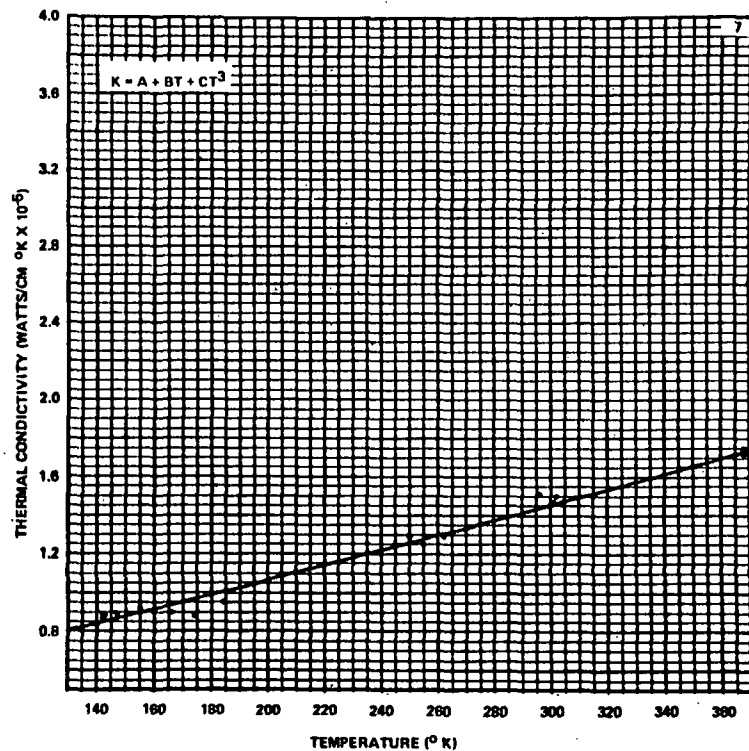
DENSITY: 0.98 g/cm³
PRESSURE: 1.3×10^{-6} N/m²

SAMPLE LOAD: 0

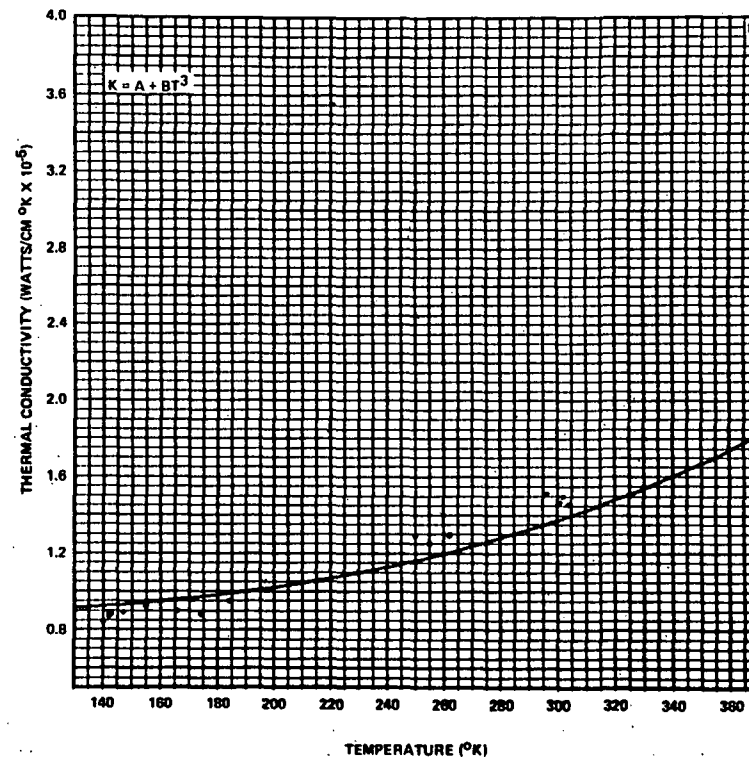
Figure 3. Thermal conductivity of basalt as a function of temperature (density = 0.98 g/cm³).

TABLE 6. FIGURE 4 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)
140	0.84
142	0.87
142	0.89
143	0.88
147	0.89
155	0.92
166	0.90
174	0.88
184	0.95
250	1.29
255	1.25
262	1.29
262	1.30
296	1.51
301	1.47
302	1.50
304	1.46
368	1.72
368	1.75
370	1.71
370	1.73



a.



b.

SAMPLE: BASALT
PARTICLE SIZE: 37-62 μm

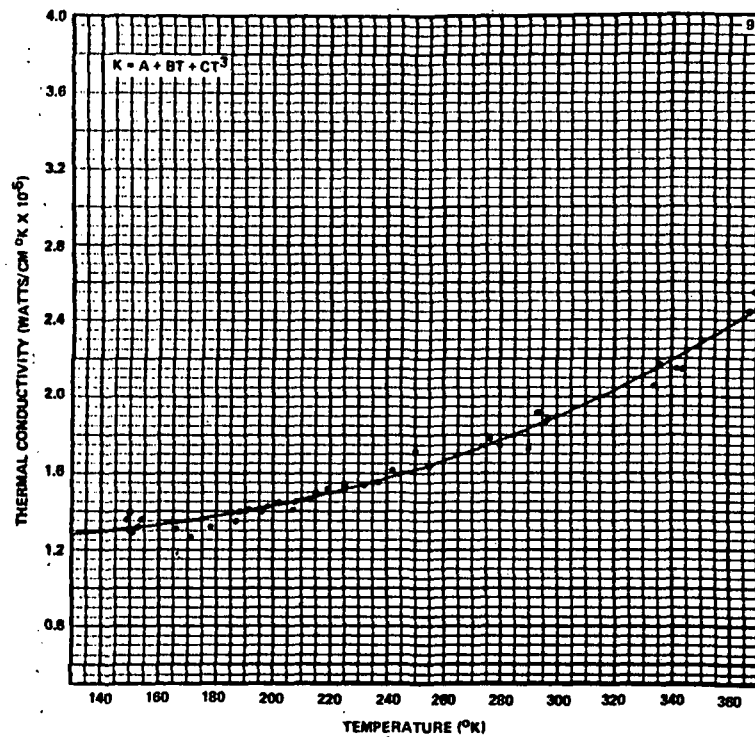
DENSITY: 1.13 g/cm³
PRESSURE: 1.3×10^{-6} N/m²

SAMPLE LOAD: 0

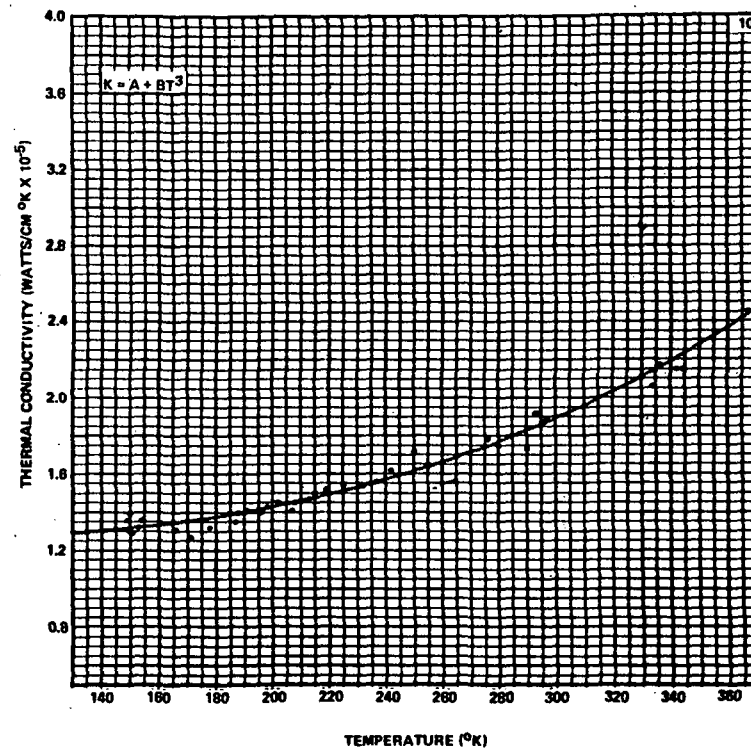
Figure 4. Thermal conductivity of basalt as a function of temperature (density — 1.13 g/cm³).

TABLE 7. FIGURE 5 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)	Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)
149	1.36	225	1.54
150	1.30	232	1.54
150	1.39	237	1.56
151	1.29	242	1.62
153	1.32	250	1.72
154	1.36	255	1.64
166	1.31	276	1.78
171	1.27	280	1.75
178	1.32	290	1.73
187	1.35	293	1.92
188	1.40	294	1.92
191	1.41	296	1.87
196	1.40	297	1.89
198	1.43	334	2.06
202	1.45	336	2.17
207	1.41	342	2.15
208	1.45	344	2.15
213	1.47	367	2.45
215	1.50	369	2.55
219	1.52	370	2.46



a.



b.

SAMPLE: BASALT
PARTICLE SIZE: 37-62 μm

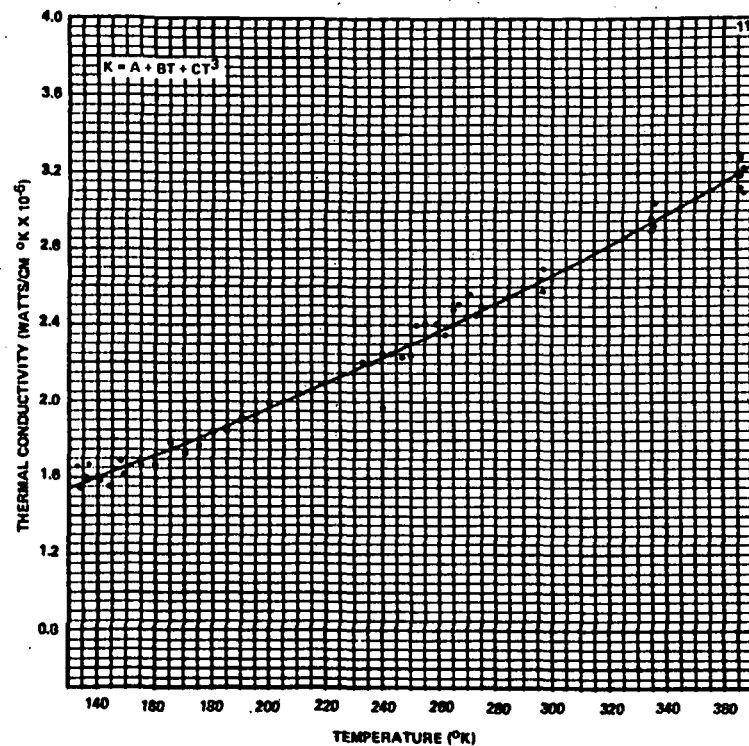
DENSITY: 1.30 g/cm³
PRESSURE: 1.3 10^{-6} N/m²

SAMPLE LOAD: 0

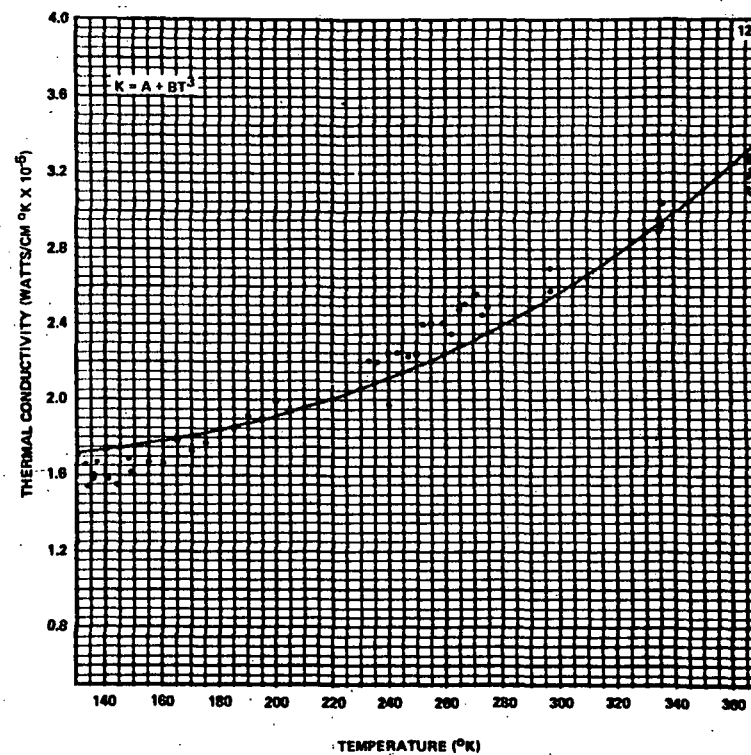
Figure 5. Thermal conductivity of basalt as a function of temperature (density — 1.30 g/cm³).

TABLE 8. FIGURE 6 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)	Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)
133	1.66	247	2.23
134	1.54	250	2.24
136	1.58	252	2.40
136	1.60	255	2.41
136	1.60	259	2.41
137	1.67	262	2.35
141	1.58	265	2.48
144	1.55	267	2.51
148	1.69	271	2.56
149	1.62	273	2.45
155	1.67	275	2.49
160	1.67	297	2.58
165	1.78	297	2.58
170	1.73	297	2.70
175	1.77	335	2.89
180	1.84	335	2.96
185	1.85	336	2.92
190	1.92	336	3.04
195	1.90	366	3.12
200	1.99	366	3.18
233	2.21	366	3.27
236	2.20	366	3.29
240	1.97	367	3.09
240	2.25	367	3.22
243	2.25		



a.



b.

SAMPLE: BASALT
PARTICLE SIZE: 37-62 μm

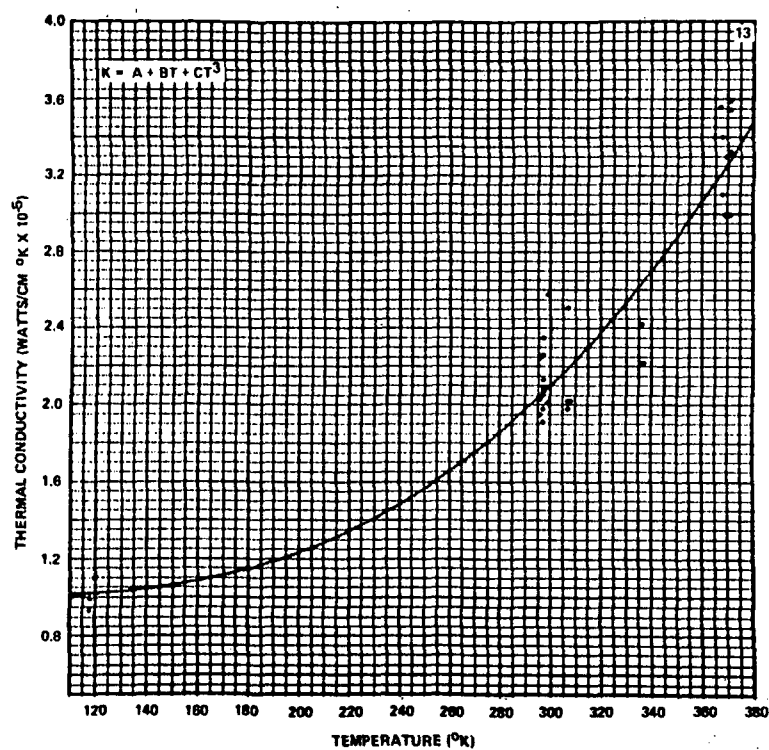
DENSITY: 1.50 g/cm³
PRESSURE: 1.3×10^{-6} N/m²

SAMPLE LOAD: 0

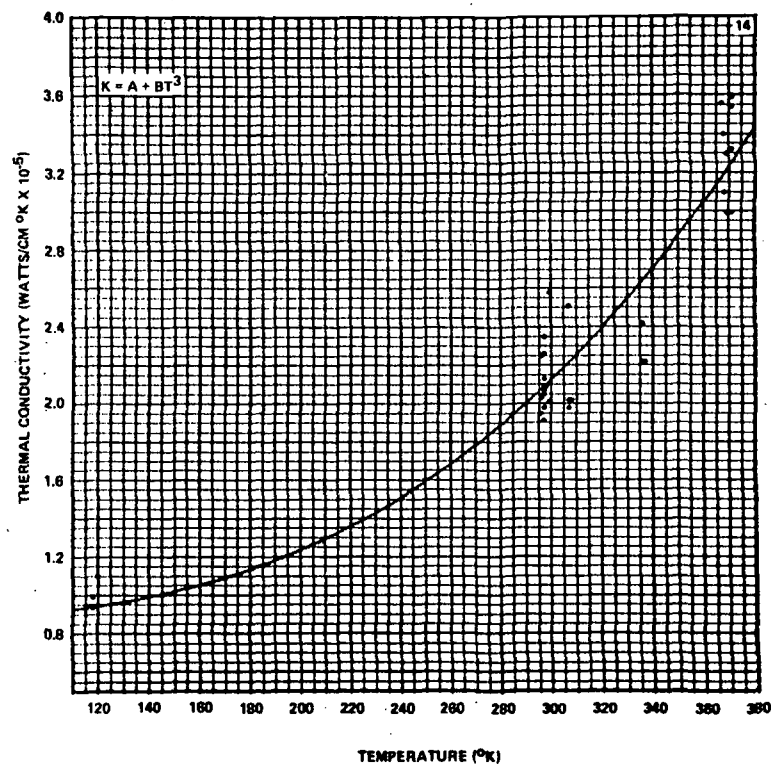
Figure 6. Thermal conductivity of basalt as a function of temperature (density — 1.50 g/cm³)

TABLE 9. FIGURE 7 DATA

Temperature (°K)	Thermal Conductivity (10^{-5} W/cm °K)
118	0.93
118	0.99
120	1.10
296	1.95
296	2.03
296	2.25
297	1.91
297	1.98
297	2.05
297	2.07
297	2.09
297	2.13
297	2.26
297	2.35
298	2.09
299	2.01
299	2.58
307	1.98
307	2.02
307	2.51
308	2.02
336	2.22
336	2.42
337	2.22
367	3.56
368	3.10
368	3.40
369	2.99
369	3.30
371	2.99
371	3.32
371	3.54
371	3.59



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 30-38 μm

DENSITY: 1.58 g/cm³
PRESSURE: 1.3×10^{-6} N/m²

SAMPLE LOAD: 0

Figure 7. Thermal conductivity of glass beads as a function of temperature (particle size — 30 to 38 μm ; measured by conventional line heat source method).

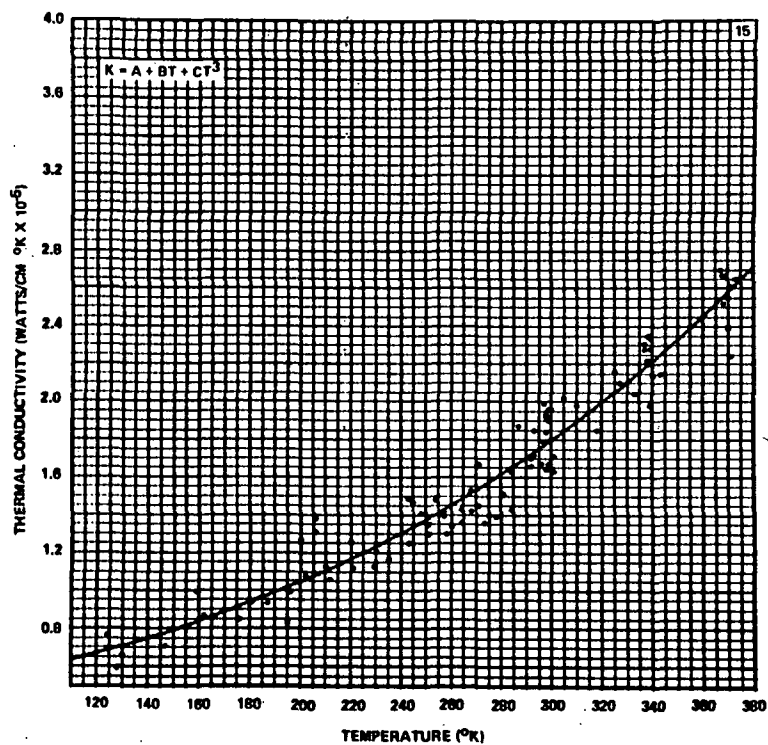
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TABLE 10. FIGURE 8 DATA

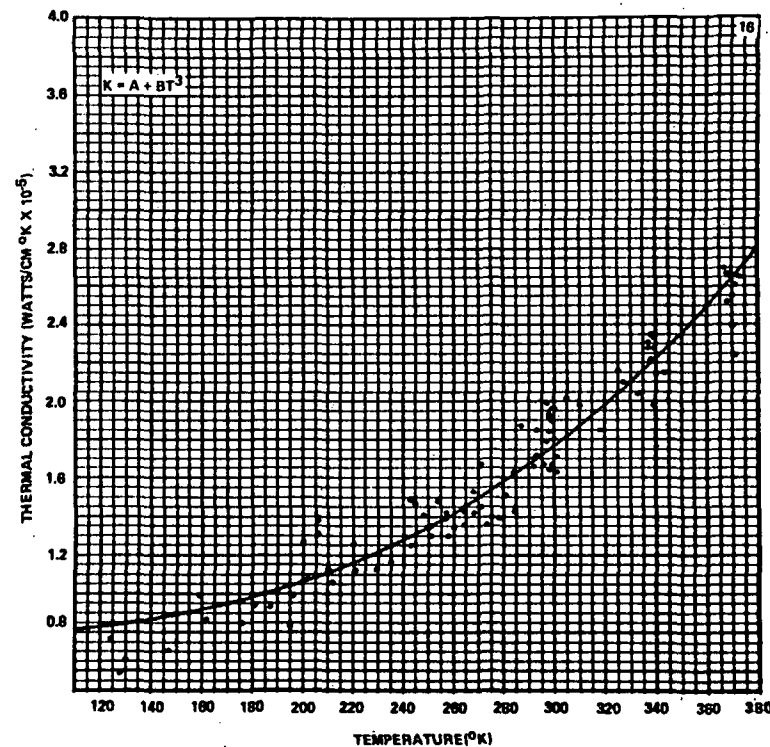
Temperature (°K)	Thermal Conductivity (10^{-5} W/cm °K)	Temperature (°K)	Thermal Conductivity (10^{-5} W/cm °K)
122	0.72	243	1.25
124	0.77	243	1.49
128	0.59	245	1.47
130	0.66	248	1.41
147	0.71	251	1.30
159	0.99	251	1.35
162	0.87	254	1.48
176	0.85	257	1.39
181	0.94	257	1.42
187	0.93	258	1.30
195	0.83	260	1.34
196	0.99	264	1.36
200	1.27	264	1.43
202	1.08	268	1.42
206	1.38	268	1.53
206	1.31	271	1.67
210	1.13	271	1.45
212	1.06	273	1.36
220	1.26	275	1.40
221	1.12	278	1.39
229	1.13	281	1.51
230	1.21	284	1.43
235	1.17	284	1.63

TABLE 10. FIGURE 8 DATA (Concluded)

Temperature (°K)	Thermal Conductivity (10^{-5} W/cm °K)	Temperature (°K)	Thermal Conductivity (10^{-5} W/cm °K)
287	1.87	325	2.16
292	1.66	327	2.10
292	1.70	333	2.04
293	1.72	337	2.28
293	1.85	337	2.31
296	1.67	338	2.22
297	1.79	338	2.35
297	1.99	339	2.35
298	1.92	339	2.34
298	1.93	339	2.28
298	1.84	339	1.98
298	1.64	340	2.14
299	1.91	343	2.15
299	1.90	367	2.70
299	1.67	368	2.67
299	1.96	368	2.52
300	1.96	369	2.67
300	1.80	370	2.39
301	1.71	370	2.55
301	1.63	371	2.61
305	2.02	371	2.24
310	1.98	373	2.65
318	1.85		



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 30-38 μm

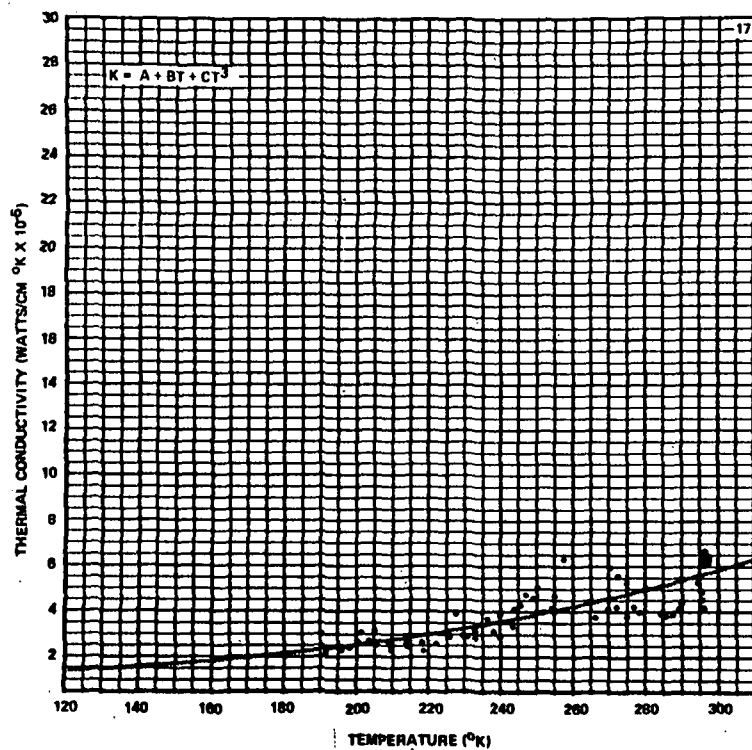
DENSITY: 1.58 g/cm³
PRESSURE: 1.3×10^{-6} N/m²

SAMPLE LOAD: 0

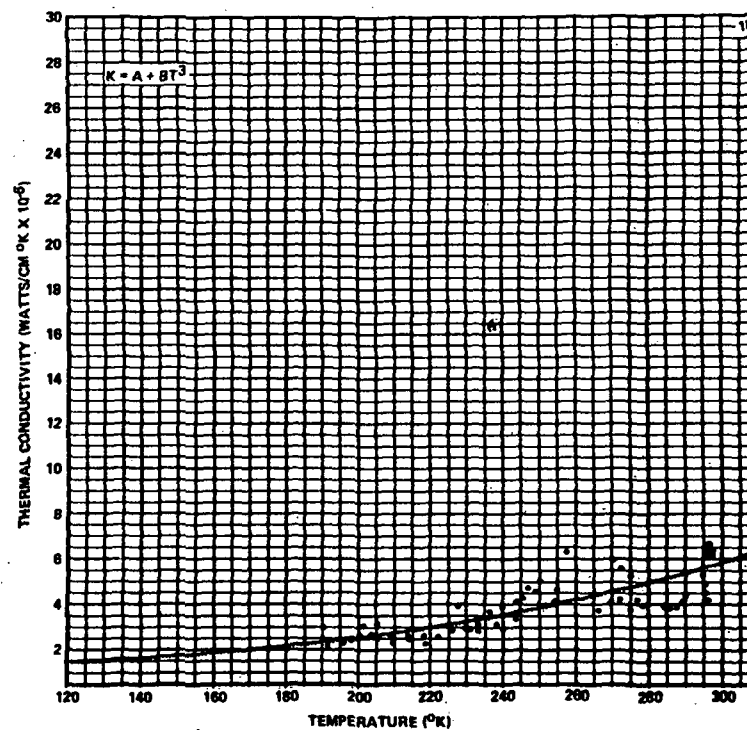
Figure 8. Thermal conductivity of glass beads as a function of temperature (particle size — 30 to 38 μm).

TABLE 11. FIGURE 9 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)	Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)
190.5	2.99	257.5	6.31
191.3	2.18	266.4	3.75
196.0	2.33	269.8	4.13
198.1	2.42	270.3	5.99
200.2	2.70	272.2	4.22
201.4	3.11	272.4	5.59
203.6	2.73	274.8	5.30
205.1	3.18	275.0	3.78
205.5	2.53	276.8	4.22
209.1	2.56	278.5	3.96
209.4	2.30	284.3	3.90
213.9	2.64	285.9	3.85
214.0	2.46	287.6	3.88
218.2	2.66	289.2	4.15
218.5	2.29	290.1	4.40
222.0	2.60	294.6	5.33
226.1	2.88	295.5	4.90
227.9	3.90	295.6	4.53
229.6	2.96	295.6	4.16
231.0	2.91	295.7	6.48
233.1	3.17	296.0	6.06
233.2	2.84	296.0	6.18
236.5	3.70	296.0	6.37
238.2	3.15	296.1	6.47
240.1	2.91	296.1	6.62
240.1	3.88	296.2	4.20
243.5	3.37	296.2	6.11
243.8	4.13	296.4	6.43
245.6	4.29	296.4	6.49
246.9	4.76	296.6	6.17
248.8	4.59	296.6	6.68
250.2	5.06	296.9	6.20
251.9	3.96	297.3	6.13
254.2	4.16	297.5	6.27
254.7	4.69	297.5	6.38



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

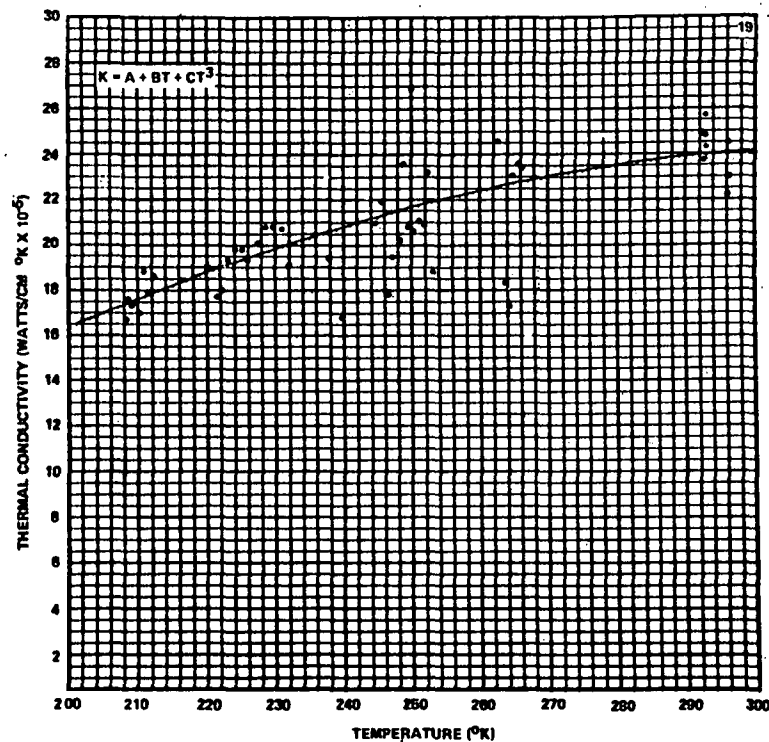
DENSITY: 1.50 g/cm³
PRESSURE: 1.3×10^{-6} N/m²

SAMPLE LOAD: 0

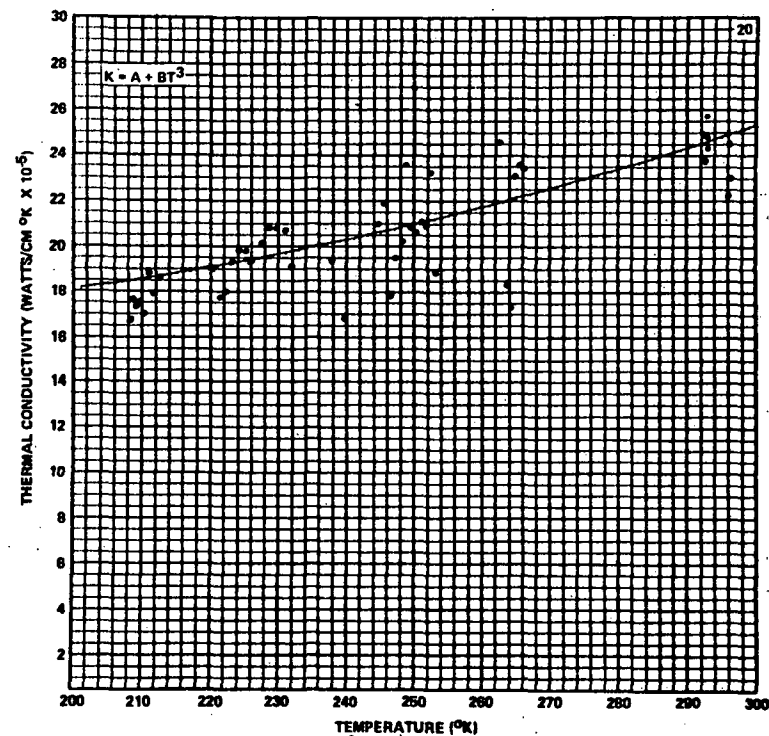
Figure 9. Thermal conductivity of glass beads as a function of temperature (sample load — 0; pressure — 1.3×10^{-6} N/m²).

TABLE 12. FIGURE 10 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)	Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
208.3	1.67	247.1	1.95
208.6	1.76	248.3	2.02
209.1	1.73	248.8	2.36
209.6	1.75	249.4	2.08
210.3	1.70	250.0	2.69
211.0	1.88	250.3	2.06
211.7	1.79	251.1	2.11
212.4	1.86	251.1	3.44
220.3	1.90	251.8	2.09
221.4	1.77	252.4	2.32
222.3	1.80	253.2	1.88
223.1	1.93	262.6	2.46
224.1	1.98	263.6	1.83
225.2	1.98	264.3	1.73
225.9	1.93	264.9	2.31
227.5	2.01	265.6	2.36
228.6	2.08	266.2	2.34
229.6	2.08	292.3	2.49
231.0	2.07	292.6	2.37
232.0	1.91	292.8	2.48
237.8	1.94	292.9	2.57
239.7	1.68	293.0	2.43
244.7	2.10	296.1	2.22
245.6	2.19	296.2	2.45
246.5	1.78	296.4	2.30



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

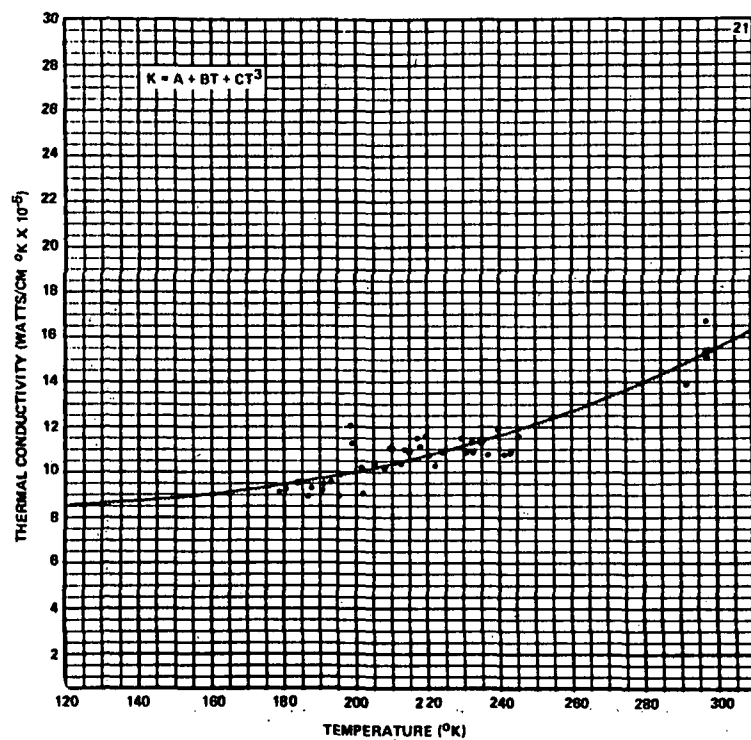
DENSITY: 1.50 g/cm³
PRESSURE: 1.3×10^{-6} N/m²

SAMPLE LOAD: 150 g/cm²

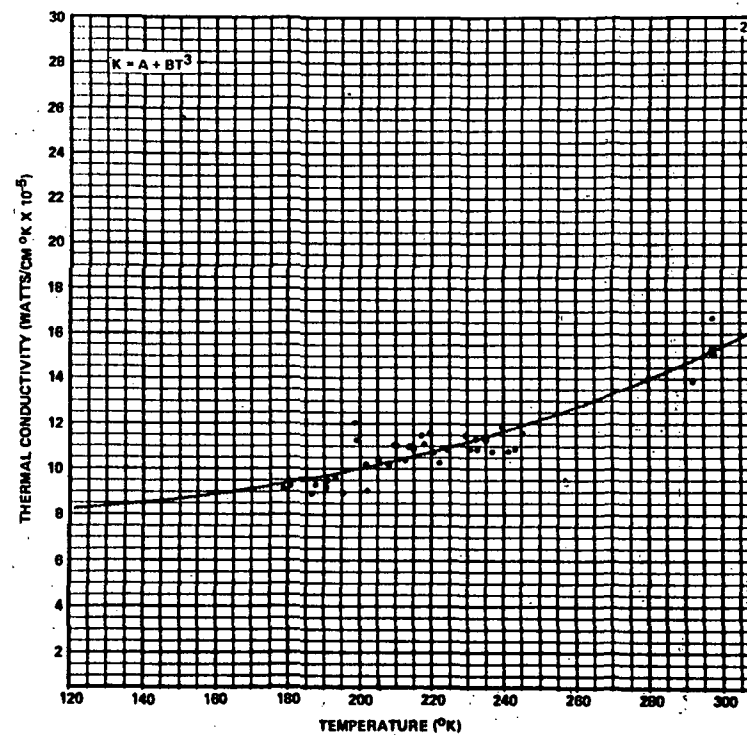
Figure 10. Thermal conductivity of glass beads as a function of temperature (sample load — 150 g/cm²; density — 1.50 g/cm³; pressure — 1.3×10^{-6} N/m²).

TABLE 13. FIGURE 11 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)	Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
178.7	0.92	217.9	1.12
180.6	0.93	219.6	1.16
183.9	0.96	220.6	1.08
186.7	0.90	222.1	1.03
187.6	0.93	224.2	1.09
190.6	0.92	229.3	1.15
191.0	0.95	230.8	1.09
193.1	0.96	232.3	1.14
195.4	0.90	232.7	1.09
196.0	0.99	234.9	1.14
198.6	1.21	235.1	1.13
199.1	1.13	236.9	1.08
201.6	1.02	239.7	1.19
202.0	0.91	241.3	1.08
205.1	1.04	243.2	1.09
208.1	1.02	245.4	1.16
209.5	1.11	292.0	1.39
210.3	1.10	297.2	1.52
212.7	1.04	297.4	1.53
213.6	1.10	297.6	1.67
215.0	1.09	297.7	1.51
217.2	1.15	297.7	1.54



a.



b.

SAMPLE: GLASS BEADS

DENSITY: 1.58 g/cm³

SAMPLE LOAD: 198 g/cm²

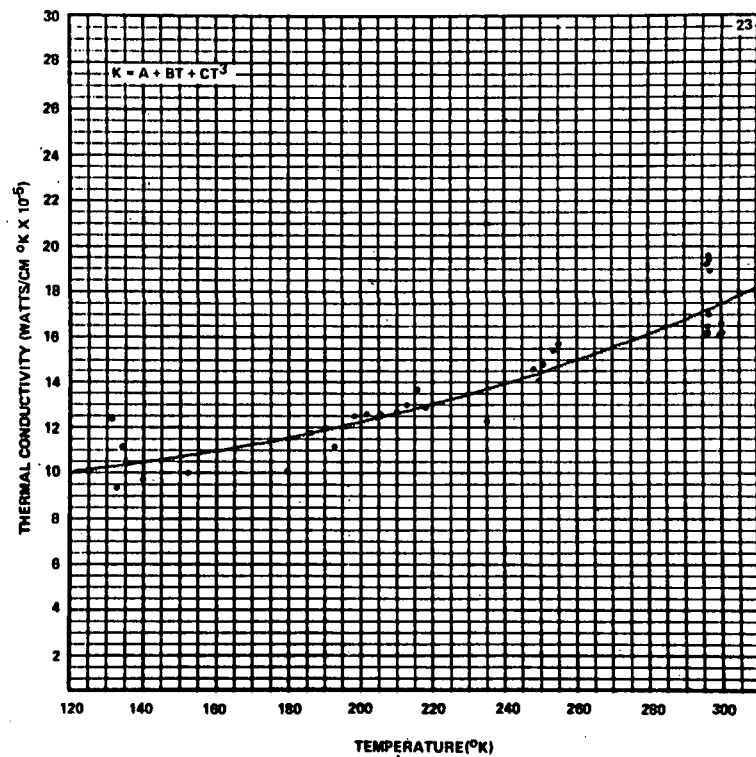
PARTICLE SIZE: 590-840 μm

PRESSURE: 1.3×10^{-6} N/m²

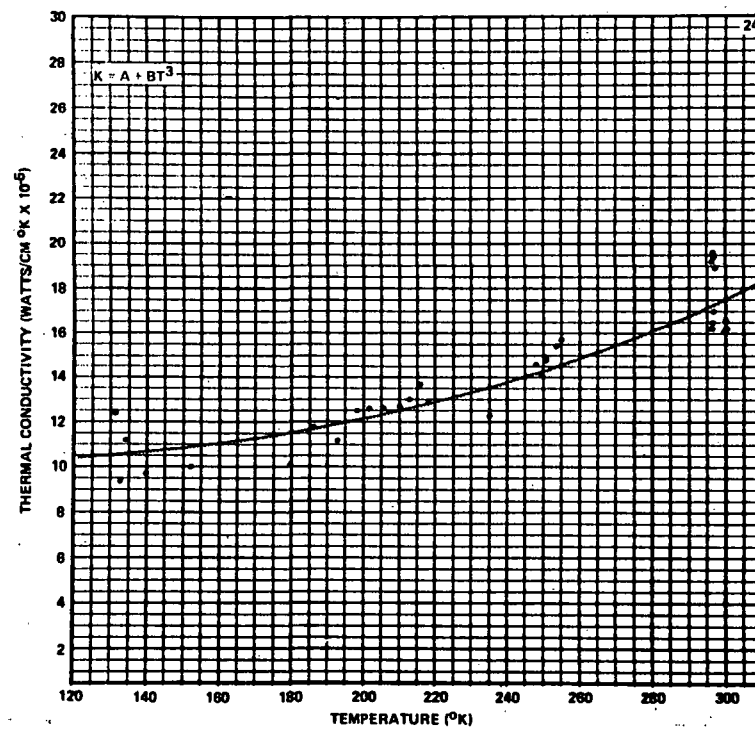
Figure 11. Thermal conductivity of glass beads as a function of temperature (sample load — 198 g/cm²).

TABLE 14. FIGURE 12 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
131.3	1.24
132.8	0.94
134.0	1.12
139.7	0.97
152.1	1.00
179.5	1.01
186.1	1.18
192.8	1.12
198.3	1.25
201.6	1.26
205.5	1.26
210.0	1.27
212.8	1.30
215.8	1.37
218.2	1.29
235.1	1.23
248.0	1.46
249.5	1.41
250.8	1.48
253.6	1.54
255.0	1.57
295.9	1.62
296.4	1.62
296.4	1.65
296.4	1.92
296.6	1.65
296.7	1.70
296.8	1.70
296.8	1.96
297.0	1.94
297.1	1.89
297.7	1.61
300.1	1.66
300.3	1.62
300.4	1.62



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

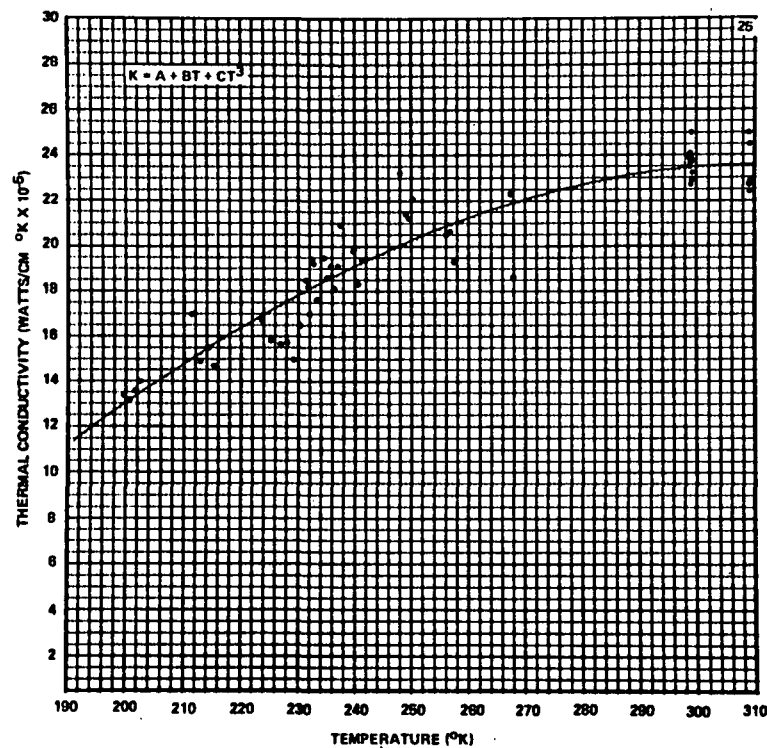
DENSITY: 1.58 g/cm³
PRESSURE: 1.3×10^{-6} N/m²

SAMPLE LOAD: 348 g/cm²

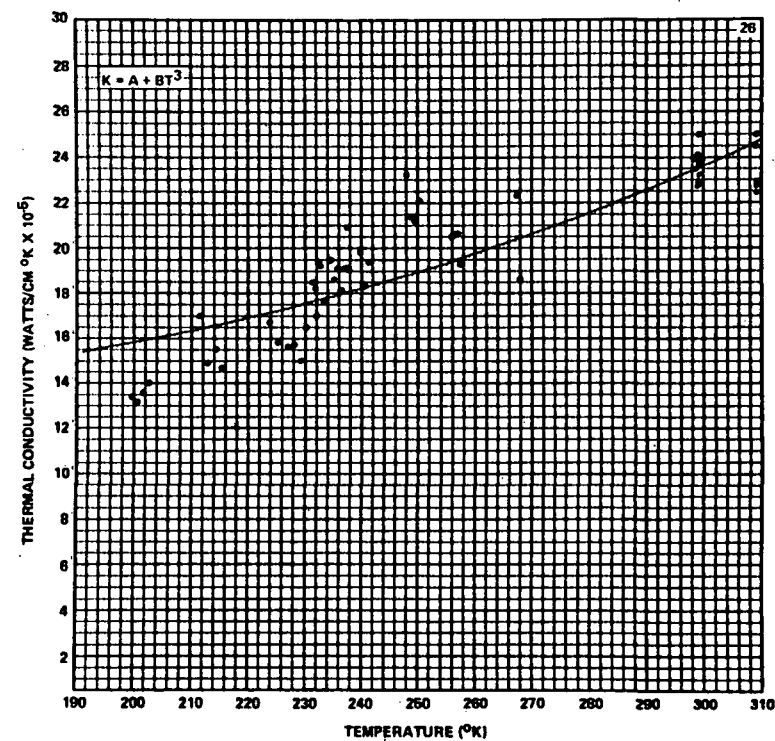
Figure 12. Thermal conductivity of glass beads as a function of temperature (sample load — 348 g/cm²; pressure — 1.3×10^{-6} N/m²).

TABLE 15. FIGURE 13 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)	Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
199.5	1.34	240.6	1.83
200.6	1.32	241.2	1.94
201.6	1.36	247.9	2.32
202.6	1.40	248.9	2.14
211.4	1.70	249.5	2.12
212.9	1.49	250.2	2.21
214.2	1.55	256.1	2.05
215.3	1.47	256.8	2.06
223.7	1.67	257.4	1.93
225.2	1.58	267.4	2.23
226.9	1.56	267.9	1.86
228.1	1.57	298.6	2.39
229.2	1.50	298.7	2.35
230.3	1.65	298.8	2.41
231.3	1.85	299.0	2.27
231.8	1.82	299.0	2.39
232.1	1.70	299.1	2.50
232.4	1.94	299.2	2.29
232.8	1.92	299.2	2.32
233.3	1.76	299.2	2.37
234.6	1.95	299.2	2.38
235.2	1.86	309.0	2.50
235.8	1.91	309.1	2.24
236.4	1.81	309.1	2.27
237.0	1.91	309.1	2.27
237.5	2.09	309.1	2.28
239.8	1.98	309.1	2.45



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

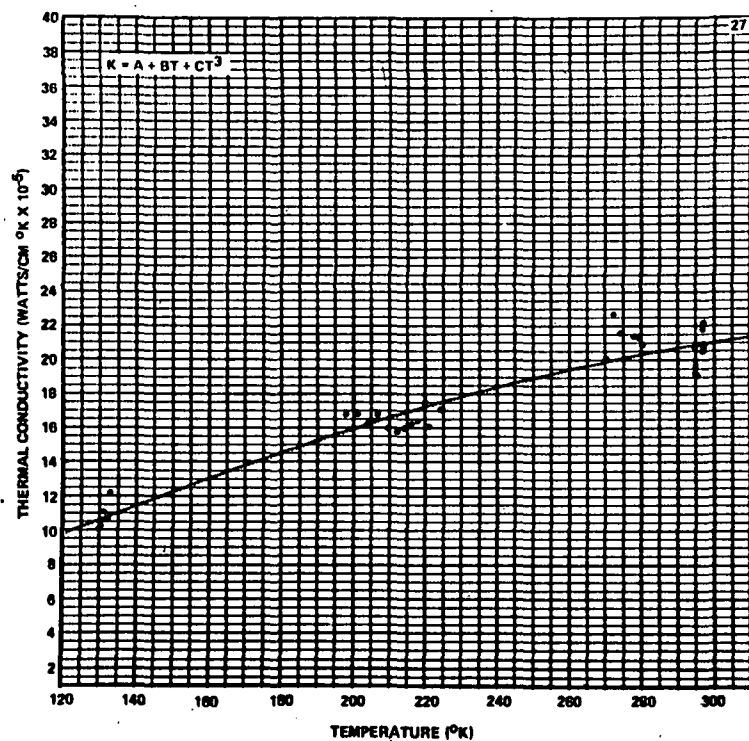
DENSITY: 1.58 g/cm³
PRESSURE: 1.3×10^{-2} N/m²

SAMPLE LOAD: 150 g/cm²

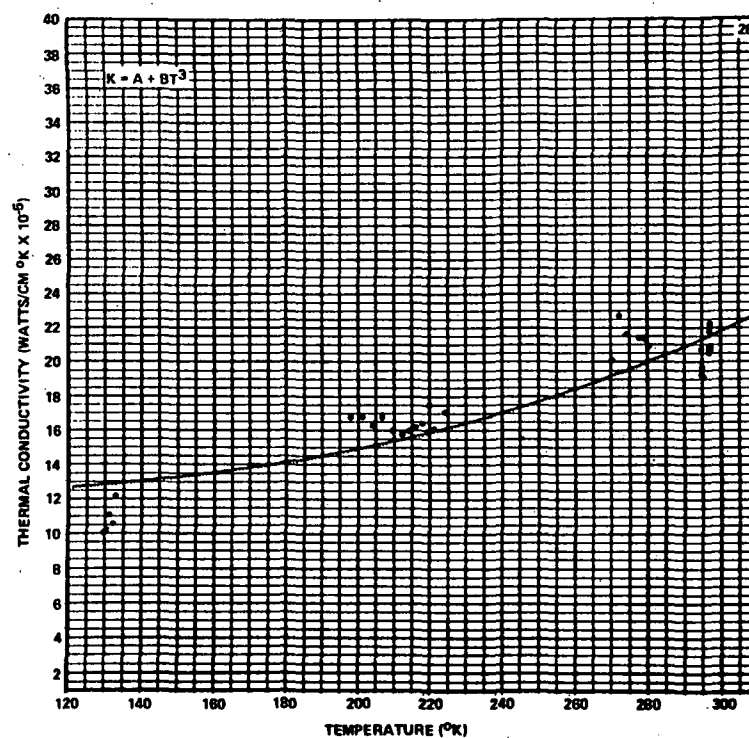
Figure 13. Thermal conductivity of glass beads as a function of temperature (pressure — 1.3×10^{-2} N/m²; sample load — 150 g/cm²).

TABLE 16. FIGURE 14 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
129.9	1.01
130.3	1.02
131.2	1.11
132.1	1.06
132.9	1.22
198.0	1.68
201.2	1.68
204.1	1.63
206.7	1.68
209.7	1.60
212.2	1.58
214.2	1.60
215.9	1.62
217.9	1.64
220.0	1.75
221.1	1.61
224.2	1.71
270.4	2.01
272.3	2.27
274.1	2.16
277.9	2.14
279.2	2.13
280.4	2.09
294.8	2.07
295.0	1.97
295.0	1.92
295.3	1.91
296.9	2.18
297.0	2.05
297.1	2.07
297.1	2.08
297.1	2.09
297.1	2.09
297.1	2.22
297.2	2.05
297.2	2.09



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

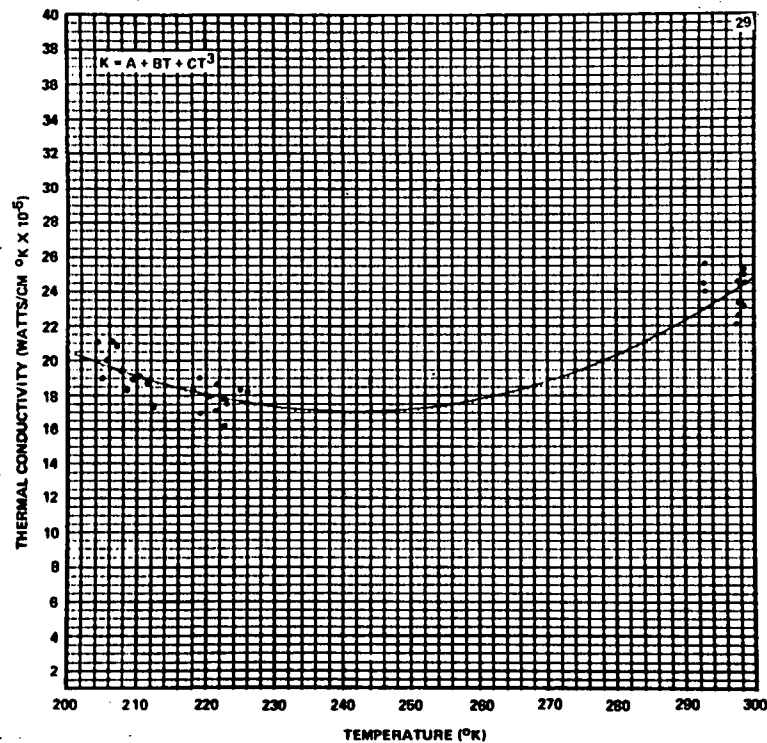
DENSITY: 1.58 g/cm³
PRESSURE: 1.3×10^{-1} N/m² (N₂)

SAMPLE LOAD: 348 g/cm²

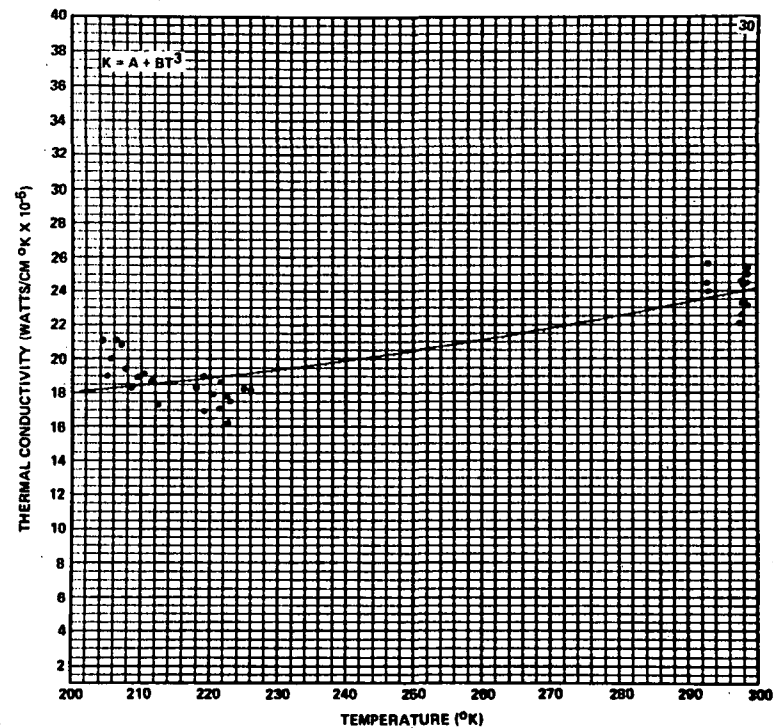
Figure 14. Thermal conductivity of glass beads as a function of temperature
[pressure — 1.3×10^{-1} N/m² (N₂); sample load — 348 g/cm²].

TABLE 17. FIGURE 15 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
204.4	2.11
205.1	1.90
205.6	2.00
206.4	2.11
207.1	2.08
207.8	1.94
208.6	1.83
209.4	1.89
210.4	1.91
211.5	1.87
212.4	1.73
218.0	1.83
219.1	1.90
219.2	1.69
220.4	1.79
220.5	1.79
221.3	1.71
221.6	1.86
222.5	1.78
222.7	1.62
223.0	1.75
225.0	1.83
226.0	1.82
292.7	2.45
292.9	2.56
293.0	2.40
297.4	2.21
297.6	2.46
297.7	2.26
297.8	2.33
298.0	2.33
298.0	2.45
298.5	2.31
298.5	2.50
298.6	2.45
298.6	2.53



a.



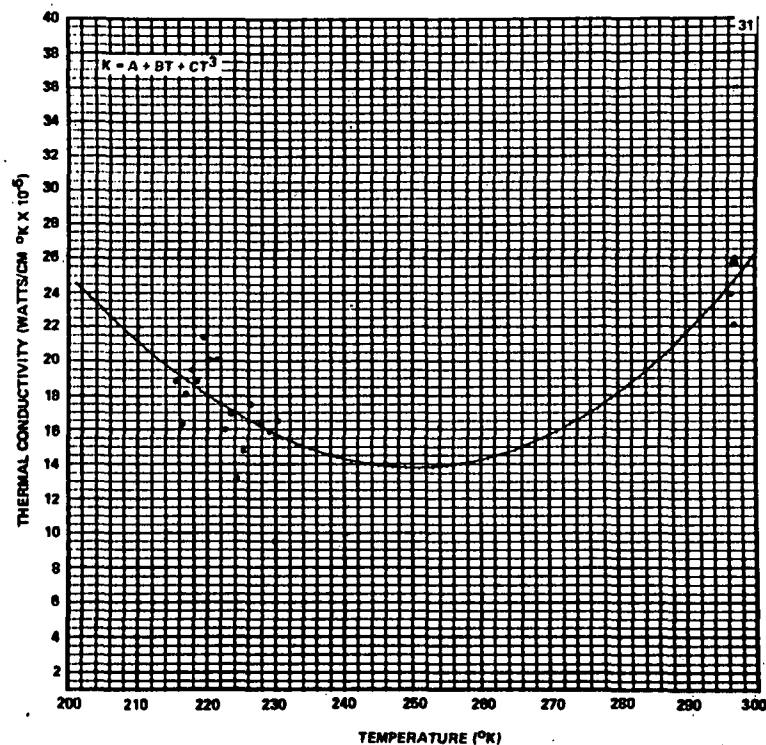
b.

SAMPLE: GLASS BEADS PRESSURE: $1.3 \times 10^{-1} \text{ N/m}^2 \text{ (N}_2\text{)}$ SAMPLE LOAD: 150 g/cm^2
 PARTICLE SIZE: $590\text{--}840 \mu\text{m}$ DENSITY: 1.58 g/cm^3

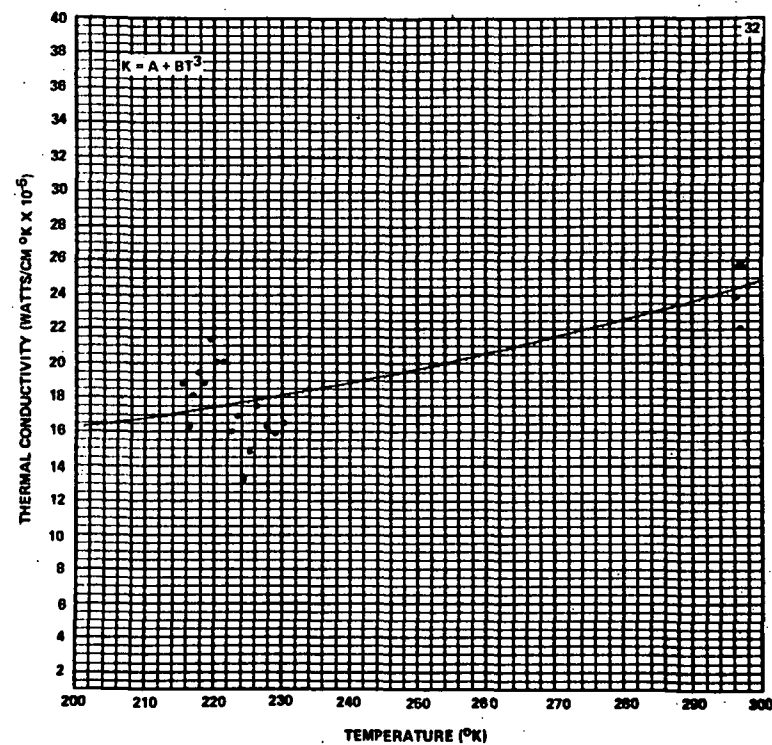
Figure 15. Thermal conductivity of glass beads as a function of temperature
 [pressure — $1.3 \times 10^{-1} \text{ N/m}^2 \text{ (N}_2\text{)}$; sample load — 150 g/cm^2].

TABLE 18. FIGURE 16 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
215.4	1.88
216.4	1.63
216.9	1.81
217.7	1.95
218.5	1.88
219.5	2.14
220.4	2.01
221.3	2.01
222.6	1.60
223.4	1.69
224.4	1.32
225.3	1.48
226.3	1.75
227.7	1.63
229.0	1.59
230.3	1.65
296.5	2.39
296.7	2.57
296.9	2.21
297.0	2.59
297.1	2.57



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

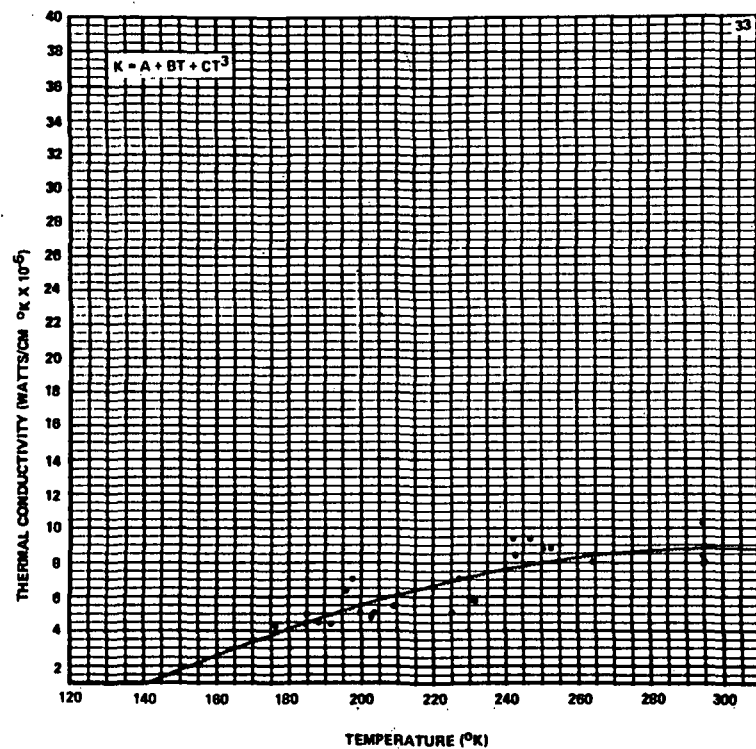
DENSITY: 1.58 g/cm^3
PRESSURE: 1.3 N/m^2 (N_2)

SAMPLE LOAD: 150 g/cm^2

Figure 16. Thermal conductivity of glass beads as a function of temperature
[pressure — 1.3 N/m^2 (N_2); sample load — 150 g/cm^2].

TABLE 19. FIGURE 17 DATA

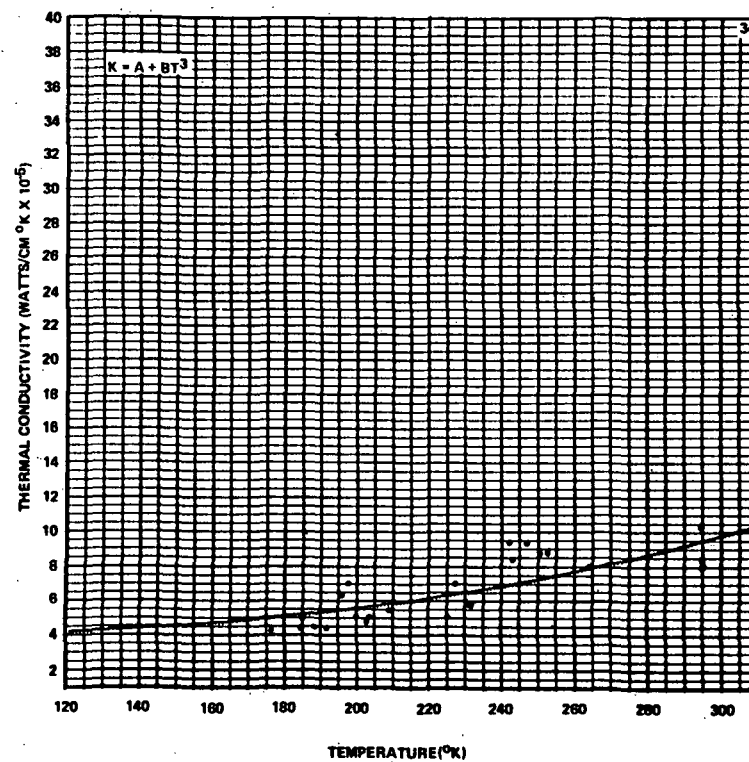
Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)
176.5	4.30
184.7	4.44
185.0	5.02
188.4	4.50
191.7	4.41
196.0	6.32
197.7	7.03
199.8	5.07
202.7	4.80
203.5	5.08
209.1	5.47
225.2	5.08
227.2	7.05
230.8	5.81
231.7	5.75
242.2	9.39
243.0	8.40
247.0	9.33
250.5	8.78
252.7	8.79
264.3	8.01
294.5	10.30
294.7	8.38
294.9	7.95
295.2	8.09



a.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

DENSITY: 1.51 g/cm³
PRESSURE: 3.25 N/m² (N₂)



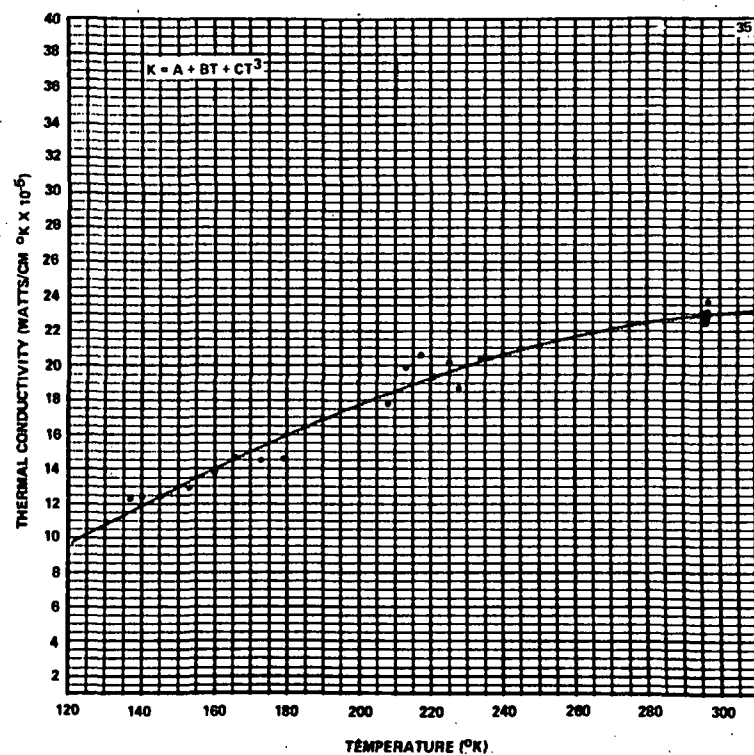
b.

SAMPLE LOAD: 0

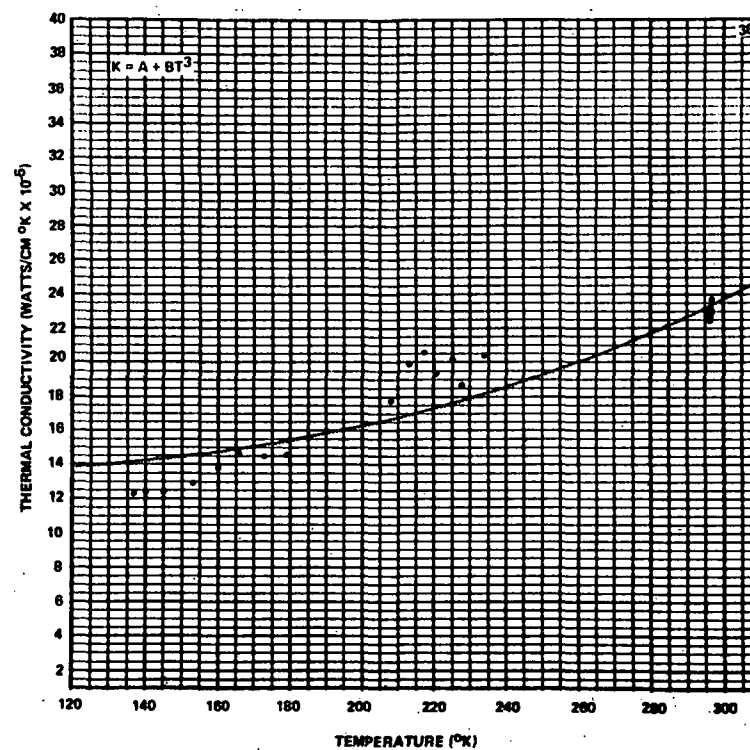
Figure 17. Thermal conductivity of glass beads as a function of temperature (density = 1.51 g/cm³; sample load = 0).

TABLE 20. FIGURE 18 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
136.9	1.23
140.2	1.24
145.1	1.24
153.2	1.29
160.1	1.38
165.7	1.47
172.9	1.45
178.9	1.46
208.1	1.78
213.1	1.99
217.2	2.06
220.5	1.93
225.0	2.02
227.9	1.87
233.9	2.04
295.7	2.29
295.8	2.27
295.9	2.30
296.3	2.24
296.5	2.27
296.6	2.27
296.6	2.30
296.7	2.29
296.7	2.30
296.7	2.31
296.8	2.30
296.9	2.37



a.



b.

SAMPLE: GLASS BEADS
 PARTICLE SIZE: 590-840 μm

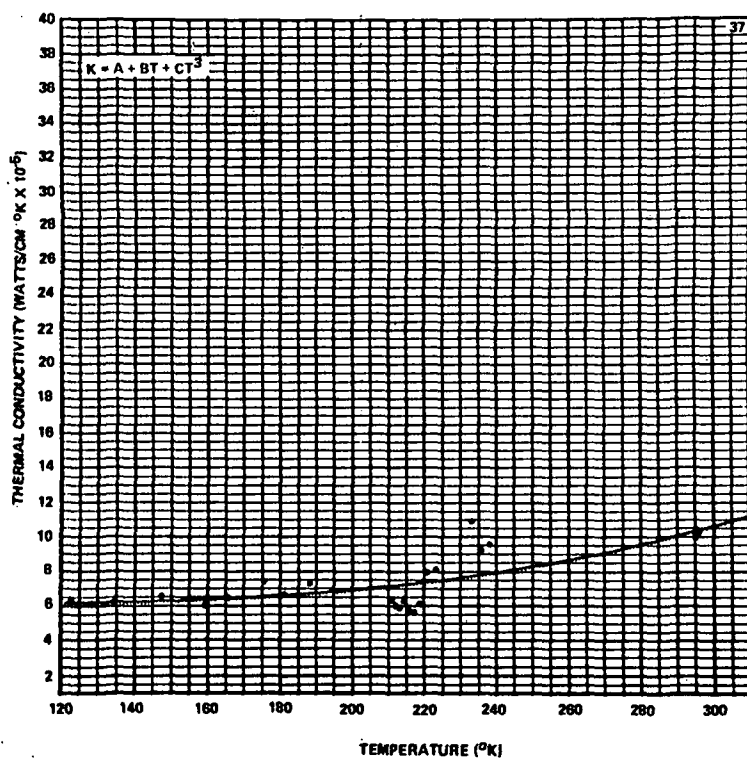
DENSITY: 1.58 g/cm³
 PRESSURE: 3.25 N/m² (N₂)

SAMPLE LOAD: 348 g/cm²

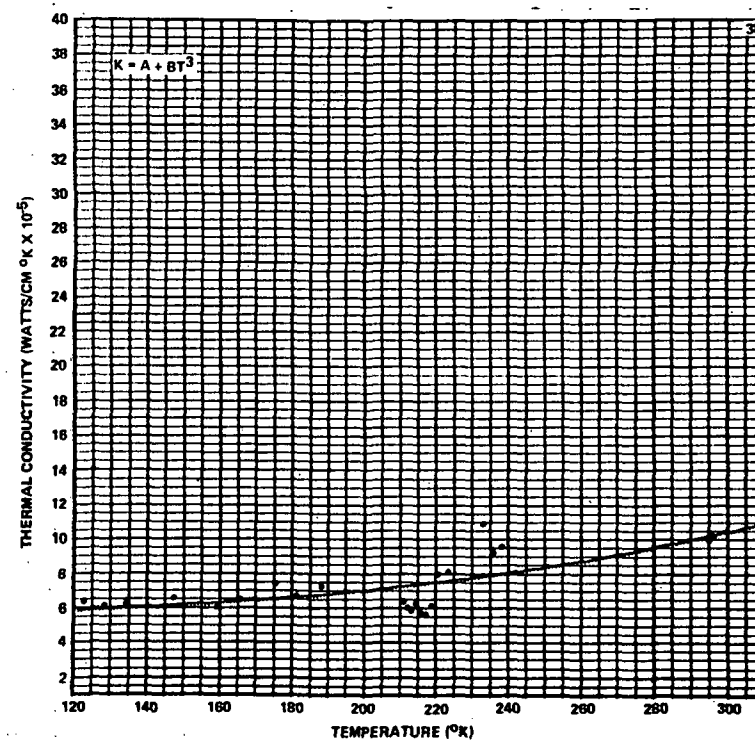
Figure 18. Thermal conductivity of glass beads as a function of temperature (density — 1.58 g/cm³; sample load — 348 g/cm²).

TABLE 21. FIGURE 19 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-5} W/cm °K)
122.9	6.32
128.4	6.17
134.2	6.26
147.5	6.56
159.3	6.07
165.5	6.51
175.5	7.41
181.1	6.69
188.3	7.29
211.0	6.36
212.1	6.03
213.2	5.87
214.4	6.29
215.7	5.76
217.2	5.65
218.7	6.17
220.7	7.97
223.2	8.14
233.1	10.90
235.8	9.26
238.3	9.61
295.1	9.97
295.2	10.20
295.4	10.20
295.8	10.30



a.



b.

SAMPLE: GLASS BEADS
 PARTICLE SIZE: 590-840 μm

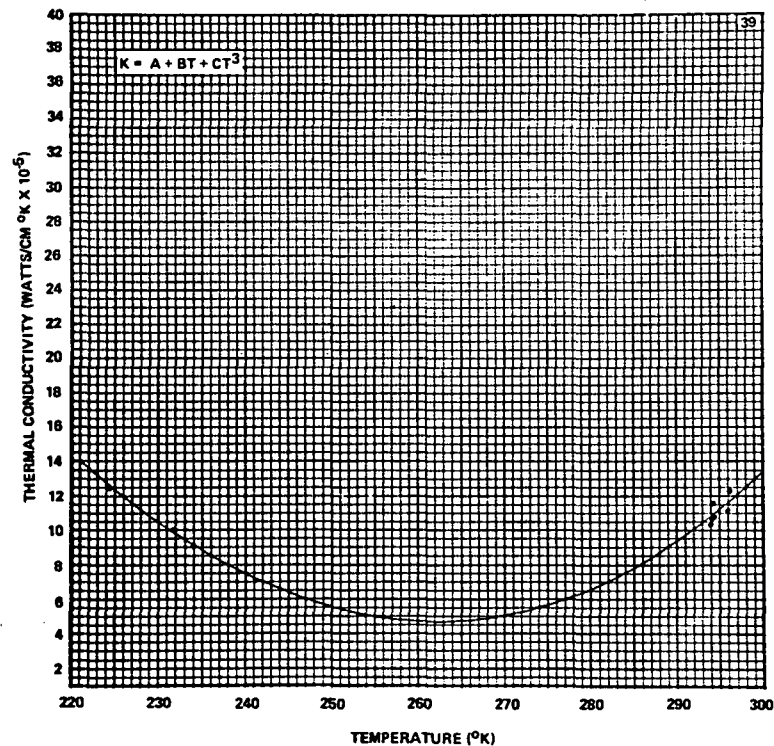
DENSITY: 1.51 g/cm^3
 PRESSURE: $5.85 \text{ N/m}^2 (\text{N}_2)$

SAMPLE LOAD: 0

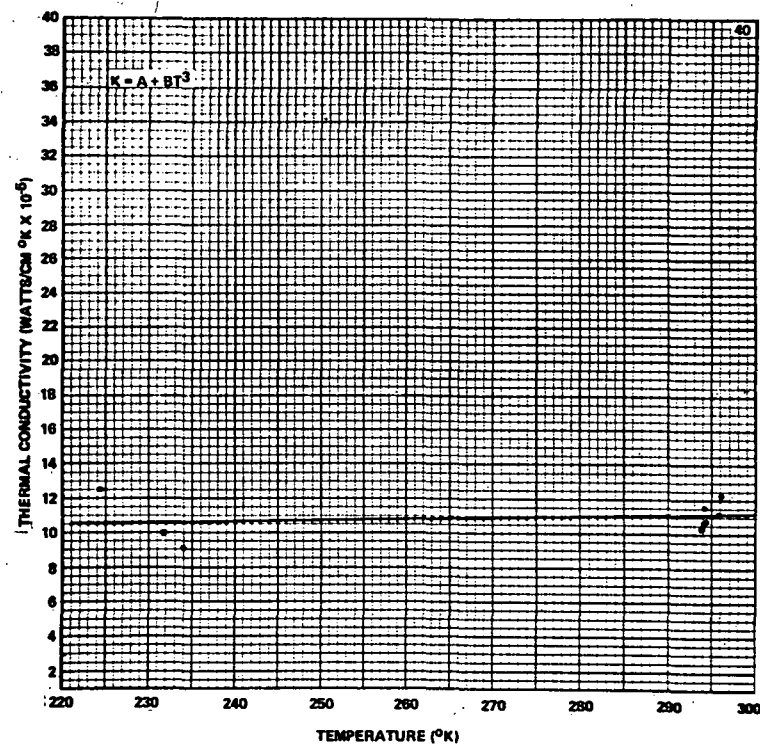
Figure 19. Thermal conductivity of glass beads as a function of temperature
 [density — 1.51 g/cm^3 ; pressure — $5.85 \text{ N/m}^2 (\text{N}_2)$].

TABLE 22. FIGURE 20 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
224.4	1.25
231.7	1.00
234.0	0.91
294.0	1.04
294.1	1.07
294.2	1.16
294.4	1.08
295.9	1.12
296.1	1.23



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

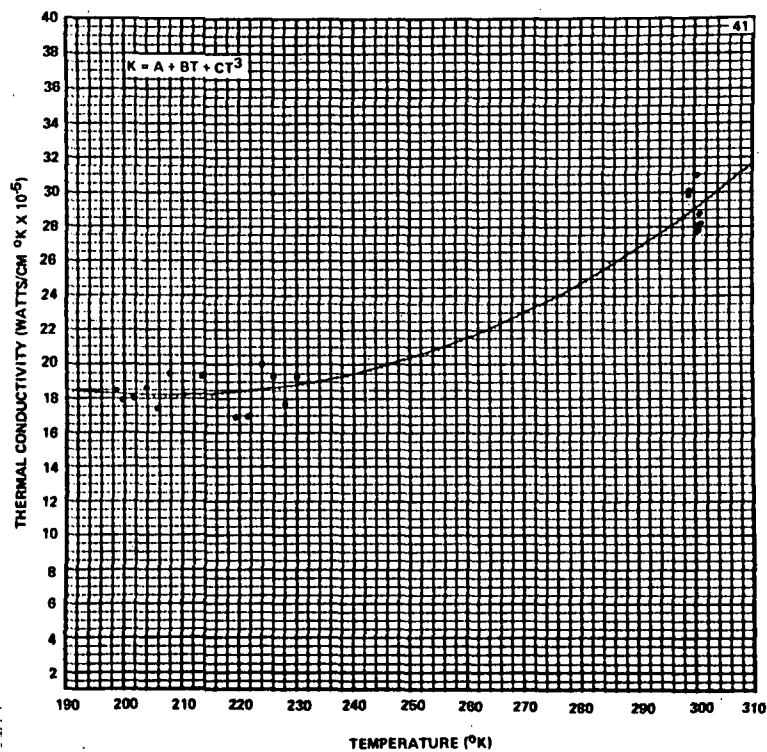
DENSITY: 1.58 g/cm^3
PRESSURE: 6.5 N/m^2 (N_2)

SAMPLE LOAD: 0

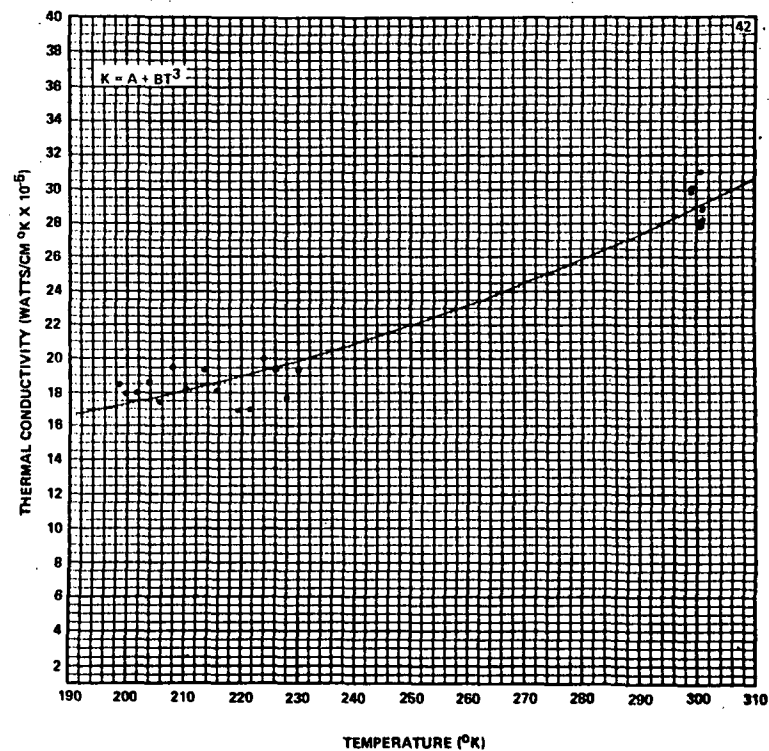
Figure 20. Thermal conductivity of glass beads as a function of temperature
[sample load — 0; pressure — 6.5 N/m^2 (N_2)].

TABLE 23. FIGURE 21 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
198.6	1.85
199.7	1.79
201.6	1.80
203.8	1.86
205.7	1.74
207.9	1.95
210.3	1.82
213.5	1.93
215.6	1.81
219.3	1.69
221.5	1.70
224.0	2.00
226.0	1.93
228.0	1.77
230.0	1.93
299.1	2.98
299.1	3.01
300.5	2.81
300.6	3.10
300.7	2.78
300.9	2.88
301.0	2.82



a.



b.

SAMPLE: GLASS BEADS
 PARTICLE SIZE: 590-840 μm

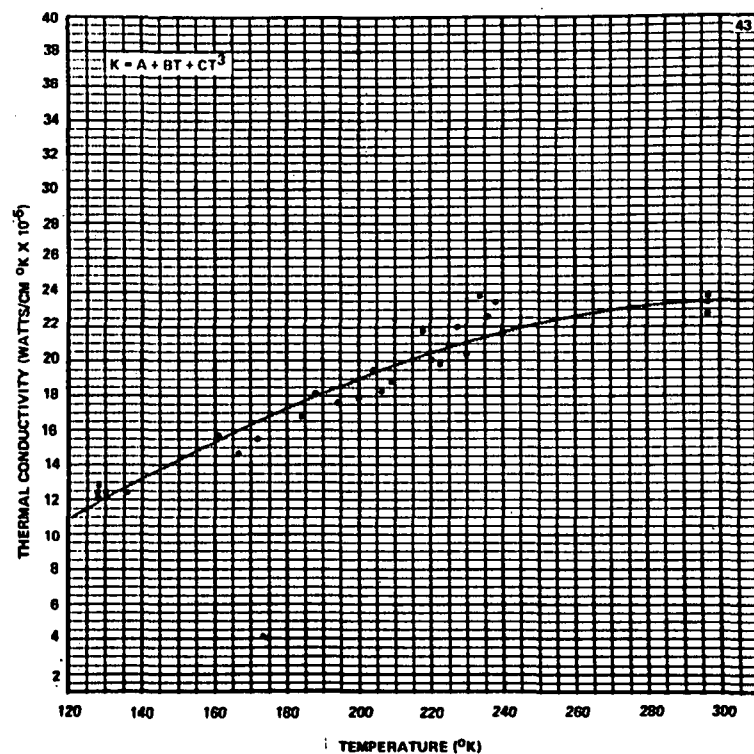
DENSITY: 1.58 g/cm^3
 PRESSURE: $6.5 \text{ N/m}^2 (\text{N}_2)$

SAMPLE LOAD: 150 g/cm^2

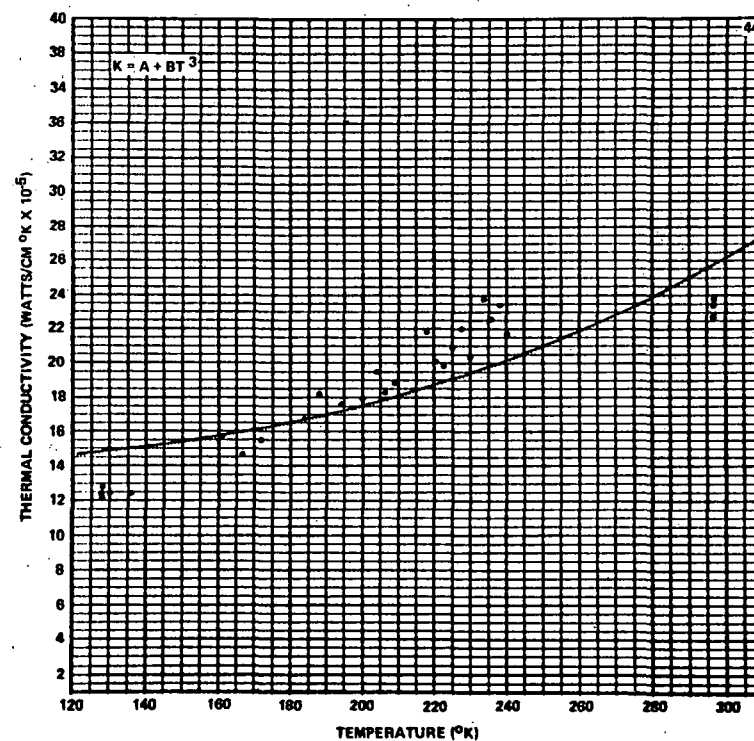
Figure 21. Thermal conductivity of glass beads as a function of temperature [sample load — 150 g/cm^2 ; density — 1.58 g/cm^3 ; pressure — $6.5 \text{ N/m}^2 (\text{N}_2)$].

TABLE 24. FIGURE 22 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
127.8	1.24
128.0	1.21
128.0	1.21
128.1	1.28
130.2	1.24
136.1	1.24
161.0	1.57
166.6	1.47
171.9	1.55
184.0	1.68
188.1	1.82
194.1	1.76
200.1	1.79
203.9	1.95
206.3	1.83
209.1	1.88
218.0	2.18
220.4	2.01
222.7	1.98
225.0	2.09
227.6	2.20
229.9	2.04
233.7	2.38
235.9	2.26
238.1	2.34
240.2	2.17
296.7	2.28
296.8	2.27
296.8	2.34
296.9	2.38



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

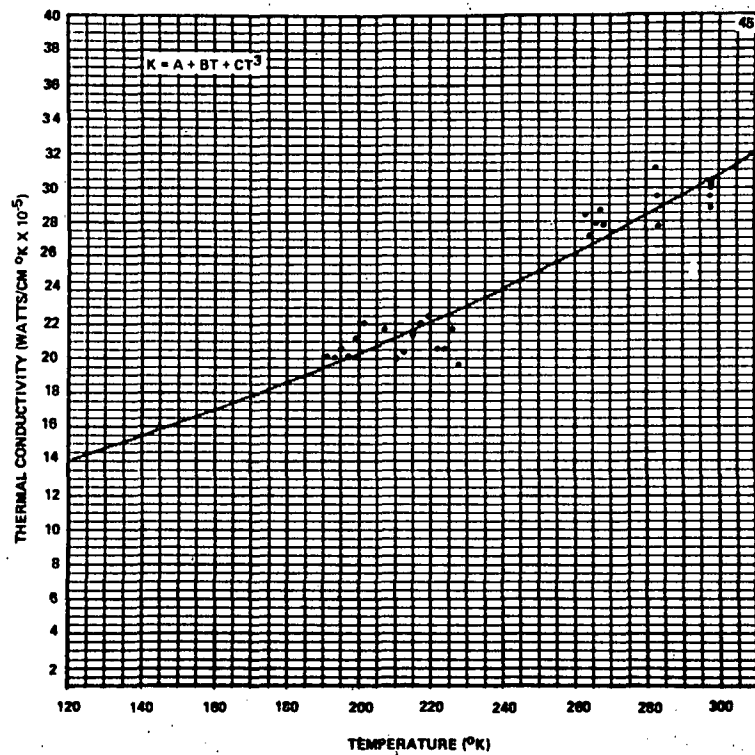
DENSITY: 1.58 g/cm³
PRESSURE: 6.5 N/m² (N₂)

SAMPLE LOAD: 348 g/cm²

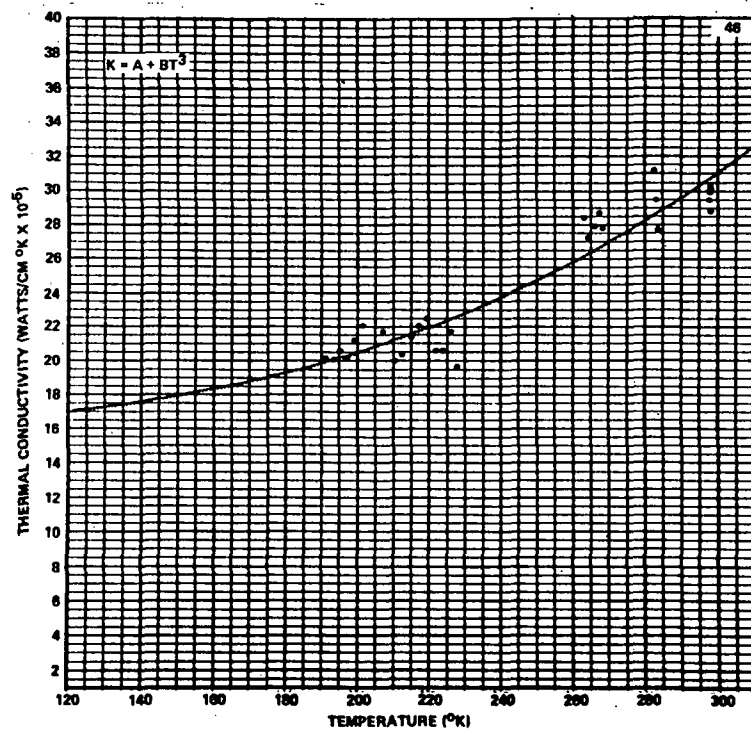
Figure 22. Thermal conductivity of glass beads as a function of temperature [sample load — 348 g/cm²; pressure — 6.5 N/m² (N₂)].

TABLE 25. FIGURE 23 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
191.2	2.02
193.3	2.01
195.2	2.06
197.0	2.02
199.1	2.12
201.4	2.21
207.2	2.17
210.5	2.00
212.5	2.04
215.0	2.14
217.2	2.21
219.3	2.25
221.8	2.06
223.9	2.06
226.0	2.17
227.8	1.97
263.2	2.84
264.2	2.72
266.2	2.79
267.3	2.87
268.4	2.78
282.5	3.12
283.1	2.95
283.5	2.77
297.7	2.95
297.8	2.88
297.9	3.00
298.0	3.02
298.1	3.03



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 590-840 μm

DENSITY: 1.58 g/cm^3
PRESSURE: 13 N/m^2 (N_2)

SAMPLE LOAD: 150 g/cm^2

Figure 23. Thermal conductivity of glass beads as a function of temperature [density — 1.54 g/cm^3 ; pressure — 13 N/m^2 (N_2); sample load — 150 g/cm^2].

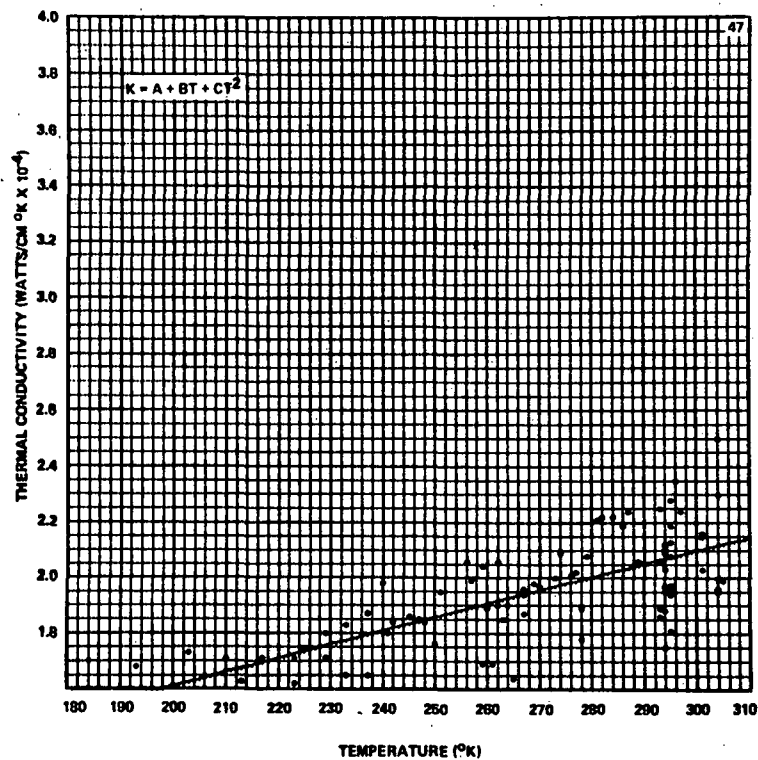
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TABLE 26. FIGURE 24 DATA

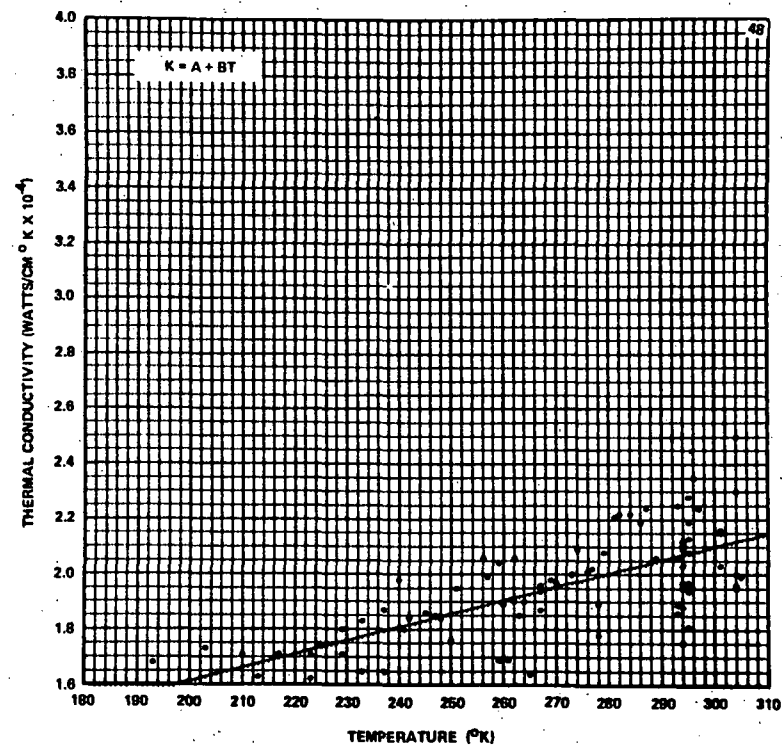
Temperature (°K)	Thermal Conductivity (10^{-4} W/cm °K)	Temperature (°K)	Thermal Conductivity (10^{-4} W/cm °K)
193	1.68	256	2.06
200	1.53	257	1.99
203	1.73	259	2.04
208	1.55	259	1.69
210	1.71	260	1.89
213	1.63	261	1.69
217	1.71	262	2.06
223	1.62	262	1.90
223	1.71	263	1.85
225	1.74	264	1.90
229	1.80	265	1.64
229	1.71	267	1.94
233	1.65	267	1.87
233	1.83	267	1.96
237	1.65	269	1.98
237	1.87	270	1.97
240	1.98	273	2.00
241	1.80	274	2.09
242	1.84	276	2.01
245	1.86	277	2.02
247	1.85	278	1.89
248	1.84	278	1.78
250	1.76	279	2.08
251	1.95	281	2.21

TABLE 26. FIGURE 24 DATA (Concluded)

Temperature (°K)	Thermal Conductivity (10^{-4} W/cm °K)	Temperature (°K)	Thermal Conductivity (10^{-4} W/cm °K)
282	2.22	295	1.96
284	2.22	295	1.94
286	2.19	295	1.97
287	2.24	295	1.81
289	2.06	295	2.08
293	2.06	295	2.19
293	1.89	295	2.13
293	1.86	295	1.95
293	2.25	295	2.28
294	1.88	296	2.35
294	1.97	297	2.24
294	2.10	301	2.16
294	1.75	301	2.15
294	2.12	301	2.03
294	1.95	304	2.00
294	2.09	304	1.95
294	2.10	304	2.30
294	2.12	304	2.50
294	2.12	304	1.96
294	2.12	305	1.99
294	2.03		



a.



b.

SAMPLE: GLASS BEADS
PARTICLE SIZE: 30-38 μm

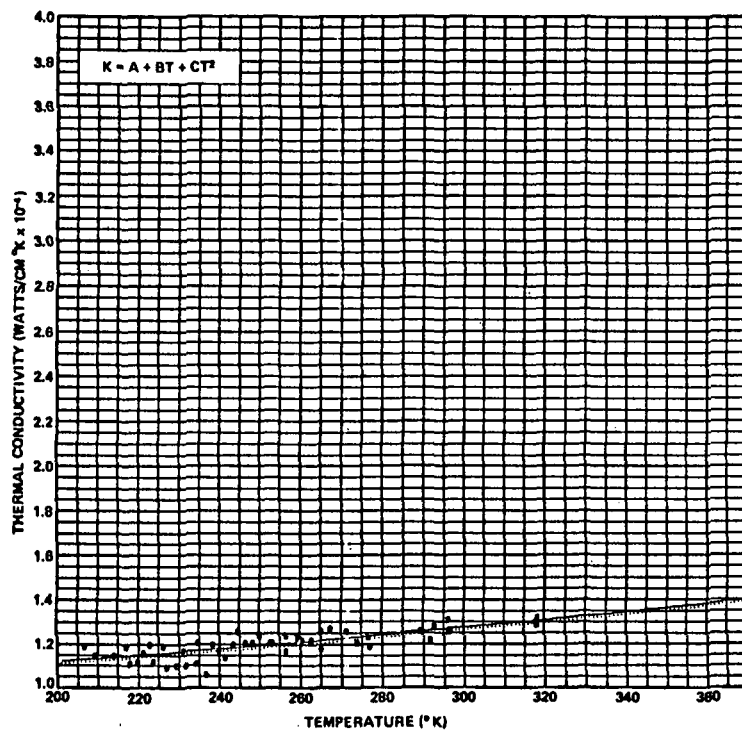
DENSITY: 1.58 g/cm³
PRESSURE: 6.9×10^2 N/m² (CO₂)

SAMPLE LOAD: 0

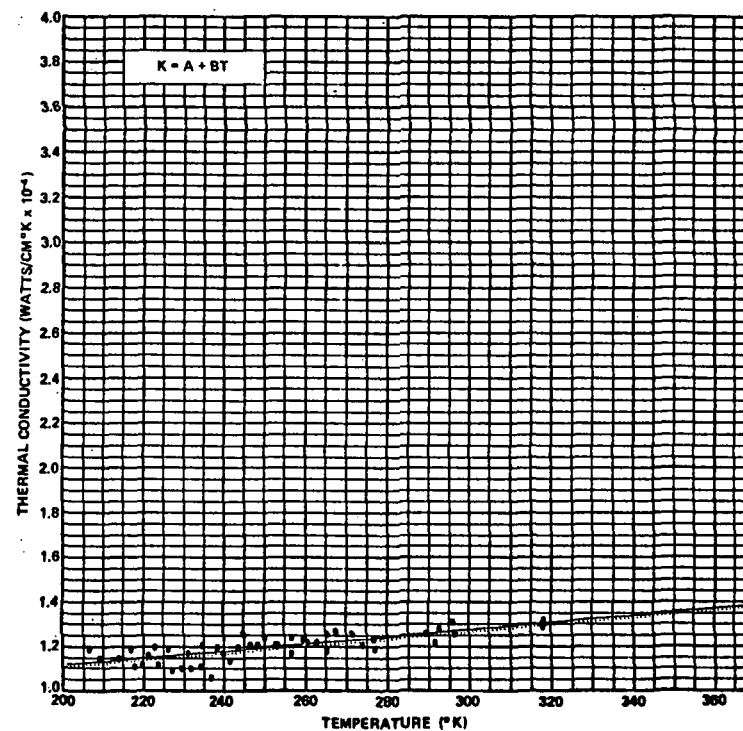
Figure 24. Thermal conductivity of glass beads as a function of temperature (particle size — 30 to 38 μm ; density — 1.58 g/cm³).

TABLE 27. FIGURE 25 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)	Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
206.6	1.19	252.6	1.21
209.3	1.15	253.2	1.21
214.1	1.15	256.5	1.17
217.0	1.19	256.5	1.24
218.0	1.11	259.2	1.23
219.9	1.12	260.3	1.22
221.3	1.16	262.6	1.22
222.8	1.20	265.2	1.18
223.8	1.12	265.3	1.26
226.2	1.19	267.6	1.27
227.0	1.09	271.5	1.26
229.5	1.10	274.0	1.21
231.1	1.17	276.5	1.23
231.9	1.10	277.0	1.19
234.3	1.11	289.4	1.26
234.7	1.21	291.5	1.22
238.3	1.20	292.7	1.28
239.9	1.17	296.1	1.31
241.6	1.14	296.1	1.26
243.4	1.20	296.7	1.26
244.8	1.26	318.0	1.30
246.5	1.21	318.0	1.30
248.3	1.21	318.2	1.29
249.9	1.24	318.3	1.32



a.



b.

SAMPLE: BASALT
PARTICLE SIZE: 37-62 μm

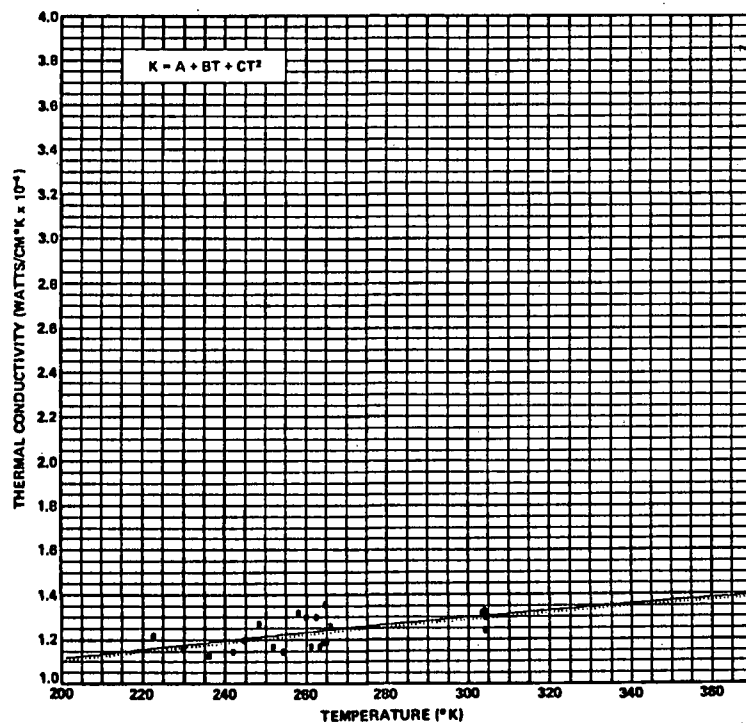
DENSITY: 0.79 g/cm³
PRESSURE: 6.9×10^2 N/m² (CO₂)

SAMPLE LOAD: 0

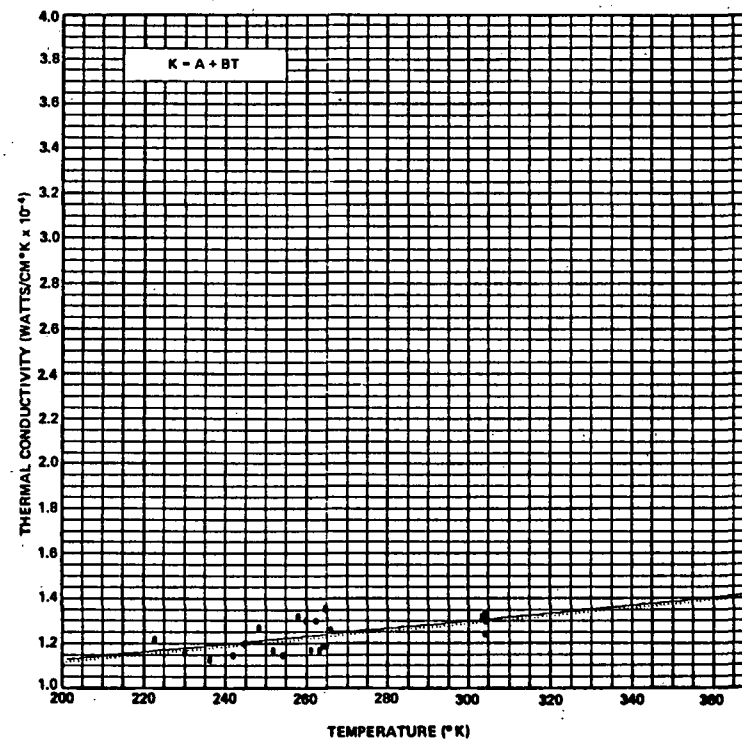
Figure 25. Thermal conductivity of basalt as a function of temperature
[density — 0.79 g/cm³; pressure — 6.9×10^2 N/m² (CO₂)].

TABLE 28. FIGURE 26 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)	Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
222.6	1.22	262.4	1.30
230.0	1.16	263.4	1.17
236.2	1.13	264.2	1.19
242.1	1.15	264.8	1.36
244.9	1.20	265.2	1.19
248.4	1.27	266.0	1.26
251.9	1.17	304.1	1.33
254.4	1.15	304.2	1.32
258.0	1.32	304.2	1.24
260.0	1.30	304.2	1.30
261.2	1.17		



a.



b.

SAMPLE: BASALT

DENSITY: 1.13 g/cm^3

SAMPLE LOAD: 0

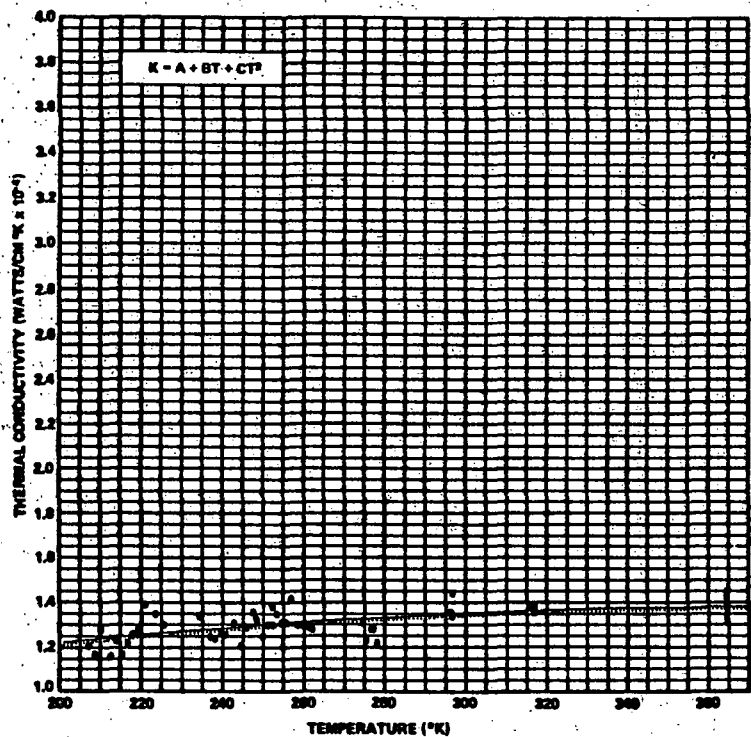
PARTICLE SIZE: $37-62 \mu\text{m}$

PRESSURE: $6.9 \times 10^2 \text{ N/m}^2 (\text{CO}_2)$

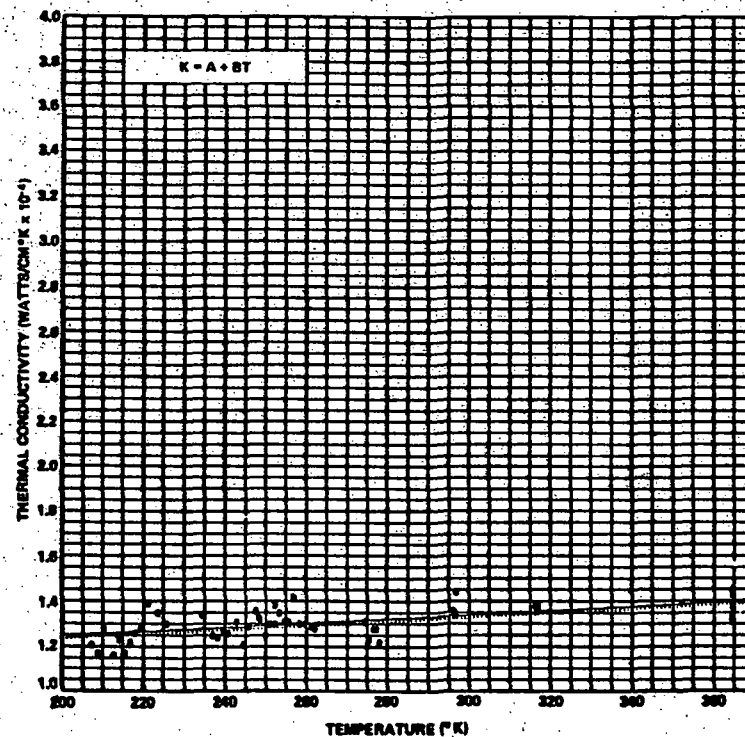
Figure 26. Thermal conductivity of basalt as a function of temperature
[density — 1.13 g/cm^3 ; pressure — $6.9 \times 10^2 \text{ N/m}^2 (\text{CO}_2)$].

TABLE 29. FIGURE 27 DATA

Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)	Temperature (°K)	Thermal Conductivity (1×10^{-4} W/cm °K)
207.2	1.21	254.5	1.31
208.8	1.17	255.6	1.31
210.2	1.28	256.8	1.42
212.6	1.16	258.4	1.30
214.1	1.23	259.9	1.30
215.4	1.17	261.2	1.29
216.6	1.22	262.2	1.28
218.0	1.26	274.6	1.31
219.4	1.28	275.6	1.23
221.1	1.39	276.5	1.28
223.5	1.35	277.3	1.28
225.6	1.30	278.1	1.22
234.3	1.34	295.9	1.36
237.0	1.25	296.3	1.36
238.2	1.24	296.6	1.34
239.6	1.27	296.7	1.34
240.7	1.26	296.9	1.44
242.7	1.31	316.1	1.38
244.6	1.21	316.6	1.36
246.0	1.29	317.0	1.36
247.6	1.36	317.0	1.38
248.3	1.33	364.5	1.33
248.6	1.32	364.5	1.38
250.0	1.25	364.5	1.43
251.1	1.30	364.6	1.37
252.2	1.30	364.7	1.32
252.2	1.38	364.8	1.45
253.4	1.35		



a.



b.

SAMPLE: BASALT
PARTICLE SIZE: 37-62 μm

DENSITY: 1.50 g/cm³
PRESSURE: $6.9 \times 10^2 \text{ N/m}^2$ (CO_2)

SAMPLE LOAD: 0

Figure 27. Thermal conductivity of basalt as a function of temperature
[density — 1.50 g/cm³; pressure — $6.9 \times 10^2 \text{ N/m}^2$ (CO_2)].

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THERMAL CONDUCTIVITY OF PARTICULATE MATERIALS:
A SUMMARY OF MEASUREMENTS TAKEN
AT THE MARSHALL SPACE FLIGHT CENTER

By James A. Fountain, Ronald W. Scott, and
Edward A. West

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WILLIAM C. SNODDY

Chief, Electromagnetic and Solid State Physics Division



W. HAEUSSERMANN

Acting Director, Space Sciences Laboratory

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Dr. Marcus G. Langseth, Jr.
Lamont-Doherty Geological Observatory
of Columbia University
Palisades, N. Y. 10964

Dr. Clifford J. Cremers
University of Kentucky
Lexington, Kentucky 40506

Dr. Alfred E. Wechsler
Arthur D. Little, Inc.
Cambridge, Massachusetts 02140

Dr. Ki-Iti Horai
NASA, Manned Spacecraft Center
Houston, Texas 77058

Dr. David D. Blackwell
Southern Methodist University
Dept. of Geological Sciences
Dallas, Texas 78222

Dr. Robert K. Carson
Institute for Astronomy
University of Hawaii
Honolulu, Hawaii 96822

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Radio Astronomy Program
Aerospace Corporation
P. O. Box 95085
Los Angeles, California 90045

Dr. K. M. Foreman
Research Department, Plant 35
Grumman Aerospace Corporation
Bethpage, New York 11714

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Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
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NASA, Manned Spacecraft Center
TN4
Houston, Texas 77058

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Brown Engineering Company
Huntsville, Alabama 35807

Dr. David Morrison
Institute for Astronomy
University of Hawaii
Honolulu, Hawaii 96822

Dr. Carl Sagan
Cornell University
Space Sciences Building
Ithaca, New York 14850

Dr. H. R. Shaw
U.S. Geological Survey
18th & F Street NW.
Washington, D.C. 20242

Scientific and Technical Information
Facility (25)
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College Park, Maryland 20740
Attn: NASA Representative (S-AK/RKT)